# ENVIRONMENT and NATURAL RESOURCES:

## *Trade-Offs and Management Options Case Study Materials for Teaching and Training*

Economy and Environment Program for Southeast Asia

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Economy and Environment Program for Southeast Asia

WorldFish Sida IDRC CRDI

The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support training and research in environmental and resource economics. Its goal is to strengthen local capacity in the economic analysis of environmental issues so that researchers can provide sound advice to policy makers. To do this, EEPSEA builds environmental economics (EE) research capacity, encourages regional collaboration, and promotes EE relevance in its member countries (i.e., Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Papua New Guinea, the Philippines, Thailand, and Vietnam). It provides (1) research grants, (2) increased access to useful knowledge and information through regionally known resource persons and up-to-date literature, (3) opportunities to attend relevant learning and knowledge events, and (4) opportunities for publication.

EEPSEA was founded by the International Development Research Centre (IDRC) with co-funding from the Swedish International Development Cooperation Agency (Sida) and the Canadian International Development Agency (CIDA). In November 2012, EEPSEA moved to WorldFish, a member of the Consultative Group on International Agricultural Research (CGIAR) Consortium. EEPSEA's structure consists of a Sponsors Group comprising its donors (now consisting of IDRC and Sida) and host organization (WorldFish), an Advisory Committee, and its secretariat.

**Environment and Natural Resources:**
***Trade-Offs and Management Options***
***Case Study Materials for Teaching and Training***

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# Foreword

I am pleased to see the publication of this important set of case study materials for teaching and training in environmental economics. It brings together a carefully selected set of case studies, each of which illustrates a broader set of classic environment and development problems commonly faced by developing countries. These include, for instance, tourism and conservation in Malaysia and Brunei; to kill or not to kill elephants in Thailand; saving the forest, the people, or both; whether or not market mechanisms can help save the environment; dealing with fuel subsidies in Indonesia; and water pollution in China, Vietnam, and the Philippines, among others.

Collectively, the case studies show us how economics can be used to analyze the trade-offs between concerns for the environment on one hand, and the need for economic development on the other.

This set of case studies can be used to teach students of economics, public policy, environmental science and management, as well as natural resource managers and practitioners about the different tensions inherent in environmental conservation and development, and how different countries have dealt with them. Students can be grouped into different stakeholders and protagonists with decision makers trying to balance competing interests, decide on whose values are prioritized, and discuss how losers could be compensated. The case studies can also be used to train natural resource decision makers on creative problem-solving by addressing these same questions.

I must say that EEPSEA is one of the most successful capacity-building programs in environmental economics anywhere in the world with an impressive alumnus of 4,000 researchers, policy makers, and other environmental leaders in Southeast Asia. This handbook is one of the many knowledge products that the program has produced to support this capacity-building effort.

This is a must-read for politicians, academics, civil society activists, and policy makers. At the Lee Kuan Yew School of Public Policy, we would certainly make use of the case study materials presented in this handbook.

EDUARDO ARARAL
Vice Dean Research
Lee Kuan Yew School of Public Policy,
National University of Singapore

# PREFACE

Since the launch of the Economy and Environment Program for Southeast Asia (EEPSEA) in 1993, the Program has issued about 400 research grants. It has also trained more than 2,500 researchers, mainly comprised of teachers of Environmental Economics courses from Southeast Asia and China. The Program has also shared with 1,200 natural resource decision makers/policy makers and about 200 journalists and NGOs how they can use economic tools in analyzing environmental problems and what kinds of interventions to implement in order to support environmental policy reforms in the region through its various workshops and policy forums.

The EEPSEA research grants generated reports that have been used as basis for making policy recommendations at the project level, with several also influencing the national policy agenda. As most of the papers are academic in nature, they are also used as reference materials to support university-based instruction on environmental and natural resource economics. Some of the reports are also developed into policy briefs that summarize its main findings for natural resource managers and policy makers. However, the Program had yet to explore the use of its research materials to support teaching and training in a more engaging way (i.e., as case study materials).

Thus, on March 2014, EEPSEA invited selected researchers, with studies on a range of natural resource issues, to develop a case study from their EEPSEA research project. To enrich the materials, one case study was added based on a research carried out by an EEPSEA Senior Researcher for another organization. During their case writing, the researchers received guidance from Prof. Eduardo Araral, Jr. of the Lee Kuan Yew School of Public Policy from National University of Singapore. The researchers' task was to use the data and analysis from their EEPSEA research to highlight the following: (1) trade-offs in the use of environment and natural resources, (2) the value of the benefits and the costs of the various options to improve environment and resource management, (3) the perspectives and interests of different actors/stakeholders in the decision-making process, (4) and the challenges faced by decision makers in addressing environmental problems. The results are the 14 problem-oriented case study papers featured in this book.

We hope that teachers of undergraduate and graduate environment and natural resource economics courses will find these materials useful in their classroom discussions. The book can also be used during training courses to engage natural resource managers to tackle complex environmental problems from the perspective of the various interest groups. The cases highlight environmental problems while providing options on how to address it, as well as discussion points that students or training participants can debate on or engage in through role-playing. The cases attempt to capture real-life situations that highlight the complexity of the environmental problems and the various issues that should be considered in deciding how to manage natural and environmental resources. In the process, we wish the users of these case studies to have fun as they engage with their classmates or fellow training participants in discussing the questions posed by our case study writers.

Herminia A. Francisco
EEPSEA Director

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# Acronyms and Abbreviations

| | |
|---|---|
| **AR** | artificial reefs |
| **BFAR** | Bureau of Fisheries and Aquatic Resources of the Philippines |
| **BOD** | biological oxygen demand |
| **BR** | Board Resolution |
| **CAC** | command-and-control |
| **CBA** | cost-benefit analysis |
| **CDM** | Clean Development Market |
| **CER** | Certified Emission Reduction |
| **C/N** | carbon/nitrogen ratio |
| **CNY** | China Yuan Renminbi |
| **CO** | carbon monoxide |
| **$CO_2$** | carbon dioxide |
| **COD** | chemical oxygen demand |
| **COI** | cost of illness |
| **CRMO** | Coastal Resource Management Office |
| **CTI** | Coral Triangle Initiative |
| **CV** | constant voltage |
| **DA** | Department of Agriculture of the Philippines |
| **DAB** | Dianchi Administration Bureau |
| **DENR** | Department of Environment and Natural Resources of the Philippines |
| **DNP** | Department of National Park Wildlife and Plants of Thailand |
| **DO** | dissolved oxygen |
| **DOF** | Department of Fisheries of Malaysia |
| **DOST** | Department of Science and Technology of Vietnam |
| **DWT** | deadweight tonnage |

| | |
|---|---|
| **ECS** | emission charge system |
| **EEPSEA** | Economy and Environment Program for Southeast Asia |
| **EPB** | Beijing Environmental Protection Bureau |
| **EPU** | Economic Planning Unit |
| **FA** | Forestry Administration of China |
| **FAD** | fish-aggregating devices |
| **FLA** | Fishpond Lease Agreement |
| **FMD** | foot-and-mouth disease |
| **HEC** | human-elephant conflict |
| **GDP** | gross domestic product |
| **GHG** | greenhouse gas |
| **grt** | gross registered tons |
| **GSF** | gas source fee |
| **IDR** | Indonesia Rupiah |
| **IEPO** | independent environmental protection organization |
| **IIF** | initial installation fee |
| **IRR** | internal rate of return |
| **IUCN** | International Union for Conservation of Nature and Natural Resources |
| **KARN** | Khap Ang Rue Nai |
| **KDRC** | Kunming Development and Reform Commission |
| **kJ** | kilojoule |
| **LGU** | local government unit |
| **LKIM** | Lembaga Kemajuan Ikan Malaysia (Fisheries Development Authority Malaysia) |
| **LNG** | liquefied natural gas |
| **LPG** | liquefied petroleum gas |
| **MDP** | Municipal Development Plan |
| **MFRMP** | Marine Fisheries Resource Management Program |
| **MME** | Ministry of Mines and Energy of China |
| **MMU** | mobile military unit |

| | |
|---|---|
| **MO** | municipal ordinance |
| **MoE** | Ministry of Energy of China |
| **MOSTI** | Ministry of Science, Technology, and Innovation of Malaysia |
| **MPA** | marine protected area |
| **MYR** | Malaysia Ringgit |
| **NDRC** | National Development and Reform Commission of China |
| **NG** | natural gas |
| **NGO** | nongovernmental organization |
| **NOx** | nitrogen oxide |
| **NPV** | net present value |
| **NTFP** | non-timber forest products |
| **O&M** | operation and management |
| **OIE** | Office International des Epizooties (World Organization for Animal Health) |
| **PHP** | Philippine Peso |
| **$PM_{10}$** | particulate matter less than 10 micrometer in diameter |
| **ppm** | parts per million |
| **RRD** | Red River Delta |
| **SBY** | President Susilo Bambang Yudhoyono |
| **SEA** | Southeast Asia |
| **SEPA** | State Environmental Protection Administration of China |
| **$SO_2$** | sulfur dioxide |
| **TCG** | technical consultation group |
| **TDP** | tradeable discharge permit |
| **TDRI** | Thailand Development Research Institute |
| **THB** | Thailand Baht |
| **TKN** | total kjendahl nitrogen |
| **TP** | tradeable/transferable permits |
| **TSP** | total suspended particulate |
| **TSS** | total suspended solids |

| | |
|---|---|
| **UPM** | Universiti Putra Malaysia |
| **USD** | United States Dollar |
| **VND** | Viet Nam Dong |
| **WQCI** | water quality composite index |
| **WTP** | willingness to pay |
| **ZTCM** | zonal travel cost model |

# Introduction on How to Use this Handbook

*Herminia A. Francisco*
Economy and Environment Program for Southeast Asia

The environmental problems of Southeast Asia (SEA) are many, wide-ranging, and growing in severity. A fixed natural resource capital, a growing population coupled with the tendency toward urbanization, rapid economic growth, and weak environmental governance all contributed to—and continue to exacerbate—the sad state of the region's environment. Changes in land uses and rising energy consumption contribute to the increasing levels of greenhouse gas emissions. The results of such irresponsible natural resource use, which also include overfishing, deforestation, and increasing solid waste disposal, among many others, manifest in the growing levels of air and water pollution, land degradation, loss of biodiversity and critical habitats, and climate-induced disasters. There is a definite need to change the way man manages his environment.

The problem is complex due to the interconnections of ecosystems. A land-use change in forestland affects downstream coastal and marine resources. There are also multiple uses that are in conflict with each other and multiple users with varied concerns and influence, each trying to get the biggest share of natural resources that they treat as open access. Communal management may exist in some localities but the weak enforcement of laws and the high cost of managing resources in a society that is increasingly becoming detached from nature further complicate the problem. Still, solutions can come about through the better understanding of these environmental problems and a mutual agreement on the needed actions from various stakeholders, which include natural resource managers and those who benefit from and produce environmental goods and services.

There are 14 cases presented in this book. They deal with issues involving (1) the conflicting uses of critical natural resources in both marine and forest areas (four cases); (2) overfishing and aquaculture pollution and efforts to restore fish habitats (four cases); (3) water pollution cases, particularly those caused by economic activities such as livestock development and the agro-processing industry (three cases); and (4) the pressure on forest resources as a result of rising energy consumption and the search for alternative energy sources (four cases).

The four cases on the conflicting use of natural resources show the complex problem of balancing conservation goals vis-a-vis development pursuits and the competing demands for natural resources. The case in Vietnam (Pham and Tran 2001) illustrates the negative impact of a development project (i.e., port area expansion) on marine protected areas (MPA), while the case based on the study of Ghani (2012) calls attention to the conflict between tourism development and MPA protection. The remaining two cases based on studies in Thailand (Nabangchang 2003; Jarungrattanapong and Sajjanand 2011) showcase the conflicts between the upland forest occupants and downstream water users in the use of watershed

forests in Northern Thailand, and between humans and elephants in Khap Ang Rue Nai Wildlife Sanctuary. These are real-life situations that exist in many parts of the region that highlight the issues that decision makers need to understand and deal with if the problem is to be addressed adequately.

The case of fish kills in Bolinao, Philippines based on the study of Sumalde et al. (2002) discusses ways to regulate overstocking of fish pens. The growing number of fish pens is associated with the increased concentration of fish feed in the water, which contributes to water pollution and is, in turn, partly responsible for the fish kills. The broader problem of lake pollution from various sources (i.e., industries, households) and their impacts on fish population is discussed in the case developed from the study of Pornpinatepong et al. (2010). The case based on the research paper of Sidique et al. (2014) in Malaysia discusses the negative environmental impacts of certain government policies aimed at increasing fish production—by giving fisherfolk incentives to invest in capital-intensive fishing gears, overfishing results. The case based on the study of Ferrer et al. (2011) highlights the important role of mangroves in shoreline protection during typhoons on top of the multiple goods and services they provide. The case challenges students to collect additional information to enable them to discuss this topic intelligently.

Of the three papers on water pollution, the case developed from the research of Catelo, Dorado, and Agbisit (2001) brings attention to the difficulty of managing nonpoint sources of pollution, particularly those coming from many small backyard pig producers dumping their wastes in a big lake. This complexity was also raised in the case crafted from the study of Nguyen and Tran (2009). Both cases will lead the students to discuss the various considerations in evaluating options to deal with wastewater pollution. The last case in this group of studies, based on the research of Wang and Wan (2013), focuses on a possible solution to a water pollution problem. It highlights the fact that there are cobenefits to interventions aimed at reducing pollution, and these too should be considered in the economic analysis of pollution control options.

The last set of papers deals with alternative energy sources in Cambodia, substitution of natural gas for coal in China, and the fuel subsidy in Indonesia. The materials for the case in Cambodia were taken from the research project of San et al. (2012). The case shows the high dependence on fuelwood of most rural communities in the country and the resulting forest depletion this brings about. It presents alternative sources of energy in terms of financial costs to the consumers and their environmental cost to society. The case of coal vs. natural gas in China aims to show the various barriers in using natural gas as a clean option to coal, and the various considerations that policy makers should look into to come up with a decision. Finally, the last paper addresses the equity vs. efficiency consideration in subsidizing fuel. It highlights the problem associated with this policy, and what options are available to meet the goal such a policy hopes to achieve.

## Purpose of the Handbook

This book contains 14 cases of real-life environmental problems in SEA. The case writers present the data and analysis of the issues and their solutions based on the research projects they did, which were all funded by the Economy and Environment Program for Southeast Asia. The problem-oriented cases end with questions posed to resource managers and/or policy makers. They are meant for training course participants or students of environment economics courses who will be asked to play the roles of decision makers, consultants, or analysts when they discuss the questions posed to them.

The end goal of putting this handbook together is to make the cases available for teaching environmental economics to students in the region. The writers demonstrate the use of economic tools in presenting their cases; students are then expected to analyze the data, the analysis, and the conclusions, and even to critique or challenge them. The cases vary in their presentation styles and in the level of details of the materials. Some have too much, others too little. This mirrors situation in real-life decision making. The analysts have the option to make some realistic assumptions on missing information where they find it necessary. They could also collect additional information to enrich their analysis or discussion. In the end, it is our hope that they will learn to make decisions regarding a complex environmental issue in the face of limited information and are able to look at things from different perspectives.

## How to Use the Handbook

The use of case studies in teaching is well-established in business school; the method is now also used in other disciplines as a way of engaging students in a collaborative, problem-solving learning experience. In essence, students are given the case material where the problem is presented, followed by an analysis of the problem and the proposed solutions, and ending with a set of questions posed to the students/training participants. The class is often divided in groups, and members are asked to play some roles as dictated in the case.

There are basic steps in doing a case study. The first is to understand the situation by reading the case. It may take more than one reading to appreciate the problem fully and the solutions that they require. Readers should take notes and sort the essential information from what may appear to be a chaotic set of information, or missing information in other cases.

Second is problem identification. This entails looking at the root causes of the problem(s) and the order by which you intend to address them.

Third is solution identification, which includes determining the criteria that will be used to assess the various alternatives. Some of the solutions are independent of each other, but some are part of a program of actions that will have to be taken up as a group. In most cases, the possible solutions are already spelled out and analyzed. You can choose to limit your

analysis to those possible solutions, but you could also point out other possibilities that the case study writer may have left out. The evaluation criteria are important and should be spelled out at this stage.

Fourth, the analysts should come up with a recommendation after having compared the alternative solutions using a set of evaluation criteria. It is important that the implementation plan or the necessary steps that must be taken up by the decision maker are spelled out as part of the recommended solution. Alternatively, one can also identify the conditions that are crucial to the success of the recommended solution.

Finally, the analysts should prepare their case analysis, which can be presented in class and/or submitted as a written report. The parts of such a report normally include the following: (1) problem definition, (2) possible solutions and evaluation criteria, (3) analysis of alternative options based on the evaluation criteria, and (4) recommended solution and critical conditions.

Please remember that there is no right or wrong answer in a case study; although these cases will challenge you to use the tools of environmental economics in analyzing the root causes of the problem and in studying the courses of actions to solve it. Users of this handbook should also keep in mind that some cases contain a lot of information—perhaps even too much than what one really needs—while others may have too little. Do not use the lack of salient information as an excuse for not answering the questions; real-life decision making requires that you decide on things given what you know. Finally, have fun in playing your role and in interacting with your classmates in this collaborative learning experience. Good luck.

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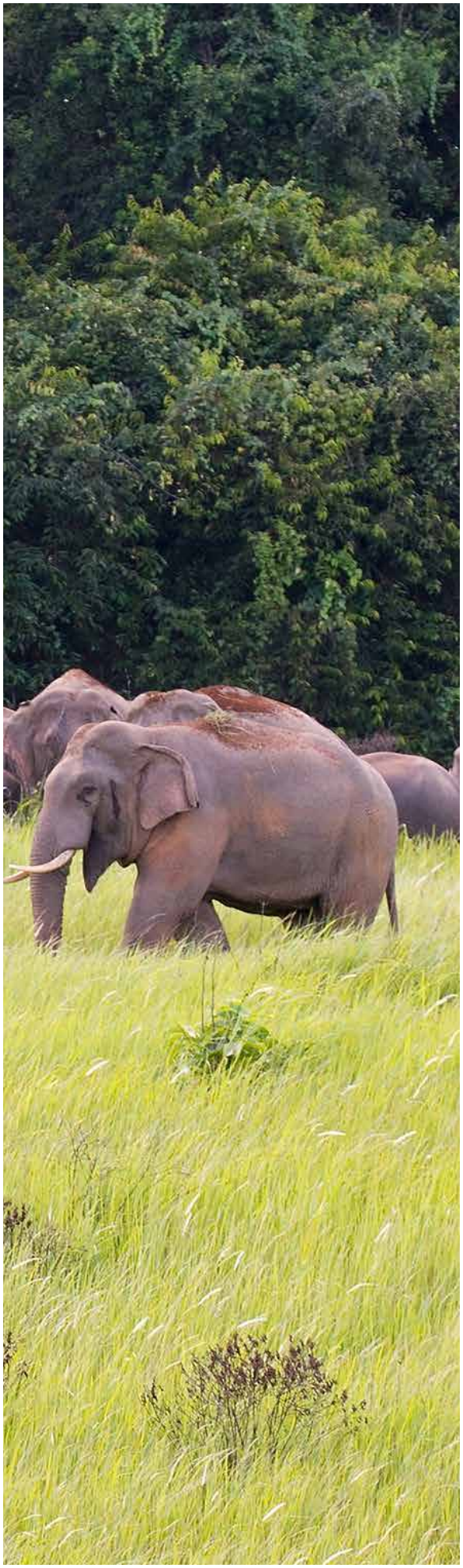
A herd of elephants at Khao Yai National Park, Thailand. Photo by Phumsith Mahasuweerachai



# 1

# Critical Natural Ecosystems: Pressures and Management Options

South Nha Trang Bay. Photo by Daniel Hoherd
under creative commons license at www.flickr.com/photos/warzauwynn/8350318119

# Protected Area or Development Project?

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Based on EEPSEA Research Report No. 2001-RR17: *Analysis of the recreational value of the coral-surrounded Hon Mun Islands in Vietnam* by Pham Khánh Nam and Tran Vo Hung Son

*This case study illustrates the trade-offs in resource allocation in public economics and the realities of operational complications associated with these trade-offs. The study shows how policy makers consider decisions that make trade-offs between development and conservation. The study also discusses the problems that accompany decisions that have to incorporate a degree of uncertainty and ambiguity, and consideration of long-term versus short-term goals.*

*The target users for this case study are policy makers on training courses or policy makers engaged in educational programs concerned with public policy or environmental management. The case study aims to*

1. *teach policy makers the concept of total economic value;*
2. *illustrate the importance of conducting a CBA to support the decision-making process; and*
3. *illustrate various social choice criteria such as economic efficiency, social equity, political concerns, and ethical issues.*

*This case study takes 90 minutes to teach using paper and pencil only. A lecture assistant should take note of all the ideas generated by the discussion.*

## Background Information

Mr. Hai, Governor of Nha Trang City, sits in his office thinking deeply about the future of Nha Trang Bay, which is recently recognized as one of the 29 most beautiful bays in the world. Mr. Hai has to decide which of the bay's assets to prioritize: (1) the Bay's beautiful coral reefs, a magnet for tourism and of worldwide ecological importance or (2) the Bay's port, an engine for development for the whole province, but one which carries an inherent risk of oil spillage, a pollution that could potentially threaten the coral reefs.

Nha Trang City is one of the most important tourism sites in Vietnam. With an airport and a seaport, Nha Trang is also strategically located along National Route 1 and the railway route that links the north and south of the country. The Hon Mun Islands comprise a group of eight islands located on the south of Nha Trang Bay. The distance between the islands and the mainland ranges from several kilometers to about 15 kilometers (km) (in the case of the furthermost islands). The Hon Mun area is representative of Vietnam's south central

biogeographic zone. Its biodiversity levels are comparable with those of the global center of coral diversity within Eastern Indonesia, the Philippines, and the Spratly Islands. The site supports a variety of habitats and ecosystems, including coral reefs, mangrove forests, seagrass beds, and an adjacent deepwater upwelling. Recent surveys have counted around 350 species of reef-building corals, 220 species of demersal fish, 106 species of mollusks, 18 species of echinoderms, and 62 species of algae and seagrass.

Hon Mun almost entirely supports the tourism industry of the city of Nha Trang. There are six dive schools based in Nha Trang, which use the area around the Hon Mun Islands for dive sites. Fishing is a major activity in the area, with 79% of household heads being fishermen. The fisheries are still small in scale and use a variety of fishing gear. Most of the fishing boats have limited power (15–45 CV), and trawl by night in offshore waters for squid. Inshore bottom trawling is also common.

The 5,300 inhabitants of the Hon Mun area depend on coral reef-based resources for their livelihoods. The three most significant productive activities for these inhabitants are, in order of importance: small-scale fisheries, lobster cage culture, and fishing crew labor. All of these activities depend on coral reefs. Recent analysis shows that the standard of living in this area is not as low as in other areas. However, the livelihoods of the poorest people are still not guaranteed in terms of food security, vulnerability, and unsustainable use of reef resources. The Hon Mun area faces high human pressure and demands on its valuable coral reef resources.

## Problems

In 2012, the Nha Trang Port Management Board submitted a plan to the Ministry of Transportation that proposed to double the port's capacity. The port plays an important role in the development of the South Central region and the Highland region of Vietnam. Coffee, pepper, and rubber from Daklak and Gia Lai provinces in the Highland region find its way to Nha Trang port for export; coal, cement, and oil move in the opposite direction up to the Highland region through the port. If the port expansion plan was to be approved, the quality of water in the Hon Mun area would probably deteriorate due to the inevitable increase in port traffic, and there would be an increased risk of oil spillage.

In recent years, with increasing economic development, the marine environment of the Hon Mun Islands has faced more and more exploitation. Coral reefs have been destroyed by many factors, mainly human activities. Exploitation by way of shipping, the use of dynamite, coral harvesting, and marine tourism have led to a decrease in marine biodiversity and precious genetic resources such as the Hawksbill turtle, and species such as false killer whales and leatherback turtles from the South China Sea. These activities obviously damage the ecosystem itself and diminish the benefits reaped from tourism in the islands.

In an attempt to tackle this problem, the IUCN (International Union for Conservation of Nature and Natural Resources) submitted a proposal to establish a Hon Mun marine protected

area (MPA). This will be a four-year management project, principally funded by international donors who have promised to contribute over USD 2 million. This financial support ensures sound management of the natural resources of the Hon Mun Islands.

## The Governor's Problem

The Governor is at a crossroad. The Vietnamese government has just issued a new national strategy for sustainable development that places great emphasis on resource conservation and environmental protection. By contrast, in its yearly performance evaluation, the central government will rank the Governor using various criteria, one of the most important of which is the Governor's efforts to increase GDP. In addition, the media is often interested in stories about fishermen trying to protect their livelihoods from developers—and the media, if used properly, can help shape the next election the Governor will have to fight.

The Governor is now faced with three project proposals; he has to choose one of them. The proposals are as follows:

1. ***Port expansion.*** If the port was to be doubled, it could receive more than 1.2 million metric tons (t) of goods (double the current volume) and could host ships with a maximum of 50,000 deadweight tonnage (DWT). The proposed shipping lane would almost run right through the area occupied by the coral reef.
2. ***Establishment of an MPA.*** An MPA would essentially ban all fishing and resource-extraction activities in the core zone, which would cover the port area and the shipping lane. The current shipping lane could be used but would need to follow the strict regulations of the MPA.
3. ***Limited port expansion and limited conservation.*** The port could expand by a further 25% of its current area. The coral reef would not be designated an MPA. Instead, current conservation activities would be enhanced by more patrol boats, education programs, and more alternative livelihood programs aimed at the villagers living on the islands.

The Governor decides that his first step in seeking a solution to his dilemma is to hold a consultation meeting that includes different stakeholder groups.

Imagine that you are invited to this meeting as a representative of one of the various stakeholder groups of the Hon Mun area.

The groups represent the following people/organizations: Nha Trang Port, the industrial sector, the Fishermen's Association, village heads, the IUCN, a conservation nongovernmental organization (NGO), and the department of tourism.

The Governor hopes the meeting will give him a deeper understanding of the problems of the Hon Mun area from the perspectives of all the related parties. He plans to make a decision following the results of the meeting.

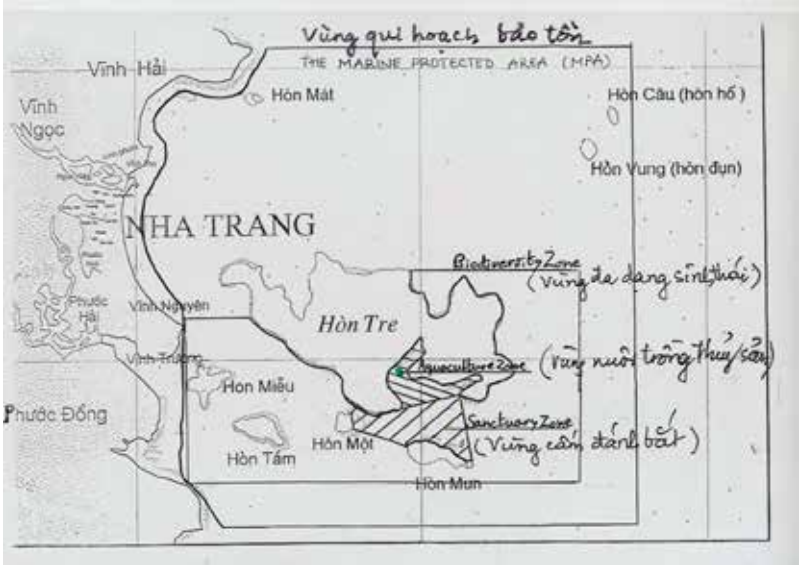
## Your Assignment

The purpose of the meeting is to find the best solution for the Hon Mun area. The Governor presents three options for the future of the Hon Mun area: (1) expanding the port, (2) establishing an MPA, and (3) reduced expansion of the port and reduced conservation of the coral reef. All the representatives of the various stakeholder groups must choose one policy option during the meeting, to be implemented in the following 12 months.

Each stakeholder group will be given an information sheet that contains data and facts about its particular field of interest, and a map that illustrates Nha Trang Bay (Figure 1). Each group should try to maximize the welfare of their group members. For example, representatives from the department of tourism care about the number of tourists in the area, the revenues of local hotels and restaurants, and how the tourism industry would operate in a sustainable manner in the long term; representatives from the environmental NGO care about keeping the marine ecosystem intact and safeguarding future biodiversity.

Each group is allowed 20 minutes to discuss their priorities. The Governor will then ask each group to present their opinions in five minutes. An open discussion will follow on which policy option should be chosen.

At the end of the meeting, the Governor will decide based on the conversations that have taken place between all the participants. The winning option will then be announced.



After being told of the Governor's decision, the participants are asked to answer the following questions:

1. Do you think the decision can help to solve the problem? Why or why not?
2. What policy would you chose if you were the Governor, whose goal is to maximize social welfare in the long-term?
3. Do you have any suggestions regarding the redistribution of benefits from the use of the area?
4. How would you balance economic efficiency and the distribution of benefits?

## Information Sheet: Tourism Department

The Hon Mun area currently attracts around 300,000 visitors per year. However, the number of visitors who dive and snorkel in the coral reef is much lower. The number of dives (known as "dive days") made every year is 18,000 (4,500 and 13,500 for domestic and foreign visitors, respectively), served by six diving clubs, all of which are based in Nha Trang City. The number of days spent snorkeling is nearly threefold, approximately 52,000 per year, of which 36,400 are undertaken by domestic visitors and 15,600 by foreign visitors.

The benefits of reef-related tourism comprise two elements: consumer surplus and producer surplus. The zonal travel cost model (ZTCM) was used to estimate the consumer surplus of the recreational activities of coral reef users (divers and snorkelers) in Hon Mun. The estimated consumer surpluses are VND 138,614 and VND 1,076,460 for domestic and foreign visitors, respectively.

The production approach was used to estimate the producer surplus of those producers who are willing to offer their services to divers and/or snorkelers. The benefits of producers were calculated through the value added of their direct and indirect expenditure related to reef activities. Producer surplus or total value added is the sum of the value added of expenditure, value added of indirect expenditure and the multiplier effect of these expenditures. The estimated producer surplus is VND 11.39 billion for the diving industry and VND 17.06 billion for the snorkeling industry.

The welfare gain of the visitors and value added to the economy from the reef-related recreation industry constitute the recreational benefits of coral reefs in Hon Mun for society. Table 1 summarizes the estimated recreational benefits of coral reefs in Hon Mun in the year of the study.

**Table 1. Annual recreational benefits of coral reefs in Hon Mun (in million VND)**

| Consumer Surplus (Net Benefit to Visitors) | | Producer Surplus (Net Benefit to Service Providers) | | | Total Recreational Benefits |
|---|---|---|---|---|---|
| Domestic Visitors | Foreign Visitors | Value Added of Direct Expenditure | Value Added of Indirect Expenditure | Multiplier Effect | |
| 5,669 (368,136) | 31,323 (2,033,969) | 9,071 (589,011) | 9,888 (642,046) | 9,479 (615,528) | 65,430 (4,248,690) |

*Note:* Figures in ( ) are the USD equivalent

## Information Sheet: The Fishermen's Association

The coral reef ecosystem is characterized by high biodiversity and productivity. These ecosystems support a great diversity of species of demersal fish, octopus, lobster, mollusks, etc. In the study area, the coral reef ecosystem even supports lobster and grouper cage culture, both of which are highly lucrative activities in the coral reef areas of Vietnam.

The production valuation method has been widely used to estimate the economic value of reef-associated fisheries. In this case study, the added value of reef-associated fisheries and aquaculture were estimated through calculating the total gross value as well as costs and labor inputs. The commercial fishery data collected covers both offshore and nearshore fisheries.

The net fisheries value per square kilometer ($km^2$) of reef was estimated based on (1) the annual potential fisheries yield per $km^2$, (2) the average market price of reef fish per kilogram, and (3) the data on the effort and cost of capturing fish. The annual potential fisheries yield was estimated as half the average reef fish standing stock (calculated from visual censuses of reef fish when detailed stock data was not available). The gross fisheries value of the reef was estimated at USD 15,538 per $km^2$ (by multiplying the annual potential fisheries yield per $km^2$ and the average price of fish).

After investigating various types of fishing gear (e.g., push net, purse seine, lift net, lobster seedling, and diving), the recent survey by researchers from Nha Trang University concluded that 70% of the gross fishing value is based on gains during the main fishing season. We took this ratio to calculate fishing costs, valued at USD 4,661 per $km^2$ of reef. The estimated value-added fishery value was USD 1,740,256 per year, calculated from the gross fishery values, fishing costs, and the total area of Hon Mun.

Lobster cage culture in the Hon Mun Islands has become a thriving industry. There are a total of 2,000 lobster cages and a total production of about 116 t[1] in the area in a year. We estimated the total value added by the coral reef in its role of supporting fisheries and aquaculture. This was based on the value added of each activity and its reef dependencies. Table 2 gives the total values of reef-based fisheries and aquaculture in the Hon Mun Islands.

[1] *One cage averagely produces 64 kilograms (kg) of lobster product.*

**Table 2. Total values of reef-based fisheries and aquaculture in the Hon Mun Islands over one year**

| Commodity | Quantity (t) | Value Added (in million VND) | Reef Dependence (%) | Value Added (USD) |
|---|---|---|---|---|
| Inshore fisheries | 13,000–70,000 kg per 1.26–2.50 $km^2$ | 1,740 | 100 | 1,740,256 |
| Lobsters | 156 | 19,313 (1,254)* | 100 | 1,254,078 |
| Groupers | Negligible** | 0 | – | 0 |
| Total | – | – | – | 1,994,334 |

*Notes:* (1) * is the USD equivalent (in '000 USD); (2) Key informant interviews revealed that the water quality in the Hon Mun area is not suitable for grouper cages because groupers are prone to disease if the water is not clean enough.

## Information Sheet: Environmental NGO

Conservation benefit is defined as a visitor's willingness to pay (WTP) to conserve coral reefs in their current state in the Hon Mun islands. The valuation question was designed to capture the nonuse values of coral reefs, such as option and bequest value. Visitors were asked to state their WTP to ensure the reefs are maintained in their current state in the Hon Mun islands. We estimated the value of the reefs to visitors, both international and domestic, to Hon Mun.

To elicit WTP of visitors for conserving biodiversity through a trust fund, bid amounts ranged from VND 5,000 to more than VND 150,000 per dive/snorkel; and from USD 1 to more than USD 10 per dive/snorkel for domestic and foreign respondents, respectively. The mean WTP per visit was estimated at VND 48,288 (USD 3.10) for domestic visitors and VND 60,830 (USD 3.90) for foreign visitors. The total conservation value of the Hon Mun coral reefs were estimated to be approximately VND 1,975 million (USD 128,245) for domestic visitors and VND 1,770 million (USD 114,945) for foreign visitors.

However, note that the conservation benefit estimated above is just a small part of the value that the coral reef ecosystem could contribute in the future. Each group is instructed to consult the additional data on the reef ecosystem presented in the background information section of this case study.

## Information Sheet: Village Head

Table 3 shows the distribution ranking of productive activities undertaken by Hon Mun villagers. Reef-related aquaculture was ranked second by 24% of villagers while near-shore fishing was ranked first by 47% of villagers. The table implies a narrow range of employment activities, mainly in fishing, aquaculture, and as crew members. These results also imply that members of the local community depend heavily on coral reefs for their livelihoods, which support 100% of their productive activities on a daily basis.

**Table 3. Distribution ranking of productive activities in Hon Mun (in %)**

| Activity | Rank | | | | Total |
|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | |
| Fishing | 47 | 10 | – | – | 57 |
| Aquaculture | 24 | 22 | 1 | – | 47 |
| Crew member | 20 | 10 | 1 | – | 31 |
| Teacher | 1 | – | – | – | 1 |
| Fish trading | 5 | 11 | 8 | – | 24 |
| Mechanic | 1 | 4 | 3 | 1 | 9 |
| Husbandry | – | – | 1 | – | 1 |
| Tailor | – | 2 | 1 | – | 3 |
| Official | – | – | 1 | – | 1 |
| Processing/handicrafts | – | 5 | 5 | – | 10 |
| Total | 98 | 64 | 21 | 1 | |

This resource dependence on reef-based fishing and aquaculture has created a highly vulnerable situation. Given the urbanization of Nha Trang City, the continued development of tourist real estate, and the impacts of global warming, the pressures on the Hon Mun coral reefs are inevitably increasing. As a result, the reef's capacity to provide benefits to the poor is reducing, putting their livelihoods at risk. The situation has worsened in Hon Mun as more conservation efforts, which tend to exclude the poor, have been introduced.

**Table 4. Summary of reef benefits to household resources**

| Resources | Benefits from Reefs | Quantitative Description |
|---|---|---|
| Natural | Reef's diversity supports small-scale and subsistence fisheries. | Boats with a length of less than 10 m and horsepower of less than 20 make up 65% of the total fleet. About 72% of interviewed households fish near the reefs and adjacent areas. |
| | Seedlings for lobster and grouper cultures. | Total value of seedlings per crop is approximately VND 46.4 billion. However, wild-caught seed stock from Hon Mun is unknown. |
| | Trash fish, fish used to feed other fish in aquaculture | The area provides around 2,500 t of trash fish per year (approximate value of VND 11.4 billion per year). |
| Physical | Gastropod shells, used in house construction | Negligible |
| | Reef provides key reference to locate fish and fishing grounds on maps | |

*Table 4 continued*

| Resources | Benefits from Reefs | Quantitative Description |
|---|---|---|
| Financial | Cash sales from fish | On average, VND 527,000 per fishing boat per day |
| | Cash sales from aquaculture | Provides 54% of cash income of those engaged in aquaculture (roughly VND 1 million per month per household) |
| | Income from tourism | Potential source, e.g., a villager operating a glassbottom basket boat can earn VND 80,000 a day |
| Human | Protein from fish | About 85% of interviewed households eat fish every day; almost 60% of interviewed households eat meat once a week |
| | Fishing is valued as a skill and in terms of knowledge. | |
| | Nearshore fishing is safer than offshore fishing. | |
| Social | Cultural exchange with tourists | Negligible |
| | The participation of women | Negligible<br>About 2.7%, 5.0%, 11.6%, and 3.9% of women participate in reef-related fishing, aquaculture, fish trading, and handicrafts, respectively. |

Mangrove forest wetlands in Sabah, Malaysia. Photo by Adrian Tritschler under creative commons license at www.flickr.com/photos/ajft/15338481298

# Mangrove Protection vs Ecotourism Development in Kota Marudu, Sabah, Malaysia

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Based on *Enhancing economic valuation of mangrove forest and its implications to coastal community*. M.Y. Fatimah; I. Faridah Hanum; and A.G. Awang Noor (eds) 2012. *In* Colours of Kota Marudu, Serdang: Universiti Putra Malaysia.

*This case study focuses on the ecosystem benefits that a well-managed mangrove ecosystem provides. It also focuses on the main contributions of this resource to rural coastal community in Kota Marudu, Sabah, Malaysia. The target audience is senior undergraduate students in environmental and resource economics or related disciplines, postgraduate students, professionals, and resource managers who will be asked to discuss how they can apply environmental and resource economics tools in evaluating potential trade-offs between ecotourism development and mangrove conservation.*

## Introduction

Ecological systems and natural capital stocks provide important services that are critical to the function of life-support systems (Constanza et al. 1997). Mangrove ecosystems provide valuable fisheries and timber species, sources of food to local people, a wide variety of materials used in medicine, sources of ecotourism and recreation opportunities, and help to maintain favorable environmental conditions. The benefits of mangrove ecosystems are enjoyed not only by local people but also by the global community. However, mangrove ecosystems have been viewed mainly as a source of fish, timber, etc. (mainly direct uses), where the latter can be converted to other wood-based products such as charcoal to meet the demand from the overseas and domestic markets. Other equally important components of mangrove forest resources (e.g., ecosystem functions, fisheries, wildlife, rattan, medicinal plants, etc.) have not attracted much attention until very recently. Viewing mangrove ecosystems as a potential source of income via fisheries, ecotourism, and knowledge-based economic activities is a relatively new phenomenon. Developing mangrove ecosystems for ecotourism has been identified as a key sector of the national economy.

Many studies have been conducted to determine the importance of mangrove ecosystems to human well-being. Russi et al. (2013) provided the economic value of mangrove and tidal marshes for four types of ecosystem services. These total economic values range between USD 1,995 and USD 215,349 per hectare (ha).

The economic values for each ecosystem are

- provisioning: USD 44–8,299 per ha;
- regulating: USD 1914–136,361 per ha;
- habitat/supporting: USD 27–68,795 per ha; and
- cultural: USD 10–2,904 per ha.

Salem and Mercer (2012) conducted a meta-analysis based on 44 studies, and found that total economic values are in the range of USD 2,772–80,334 per hectare per year with a mean of USD 28,662 per hectare per year and a median of USD 3,847 per hectare per year. Brander et al. (2012) estimated the value of ecosystem services provided by mangroves in Southeast Asia using the meta-analysis method. The mean and median values standardized to USD per hectare per year in 2007 prices were found to be USD 4,185 and USD 239 per hectare per year, respectively. The estimated foregone annual benefits in 2050 were estimated to be USD 2.2 billion, with a prediction interval of USD 1.6–2.8 billion.

In Malaysia, some of the economic values of mangroves have been estimated by various researchers. The total economic value, including nonmarket and net market values, derived from mangrove products and services on the west coast of Peninsular Malaysia (83,259 ha of mangroves) has been estimated at USD 1.38 billion, with an annual estimated value of USD 16,563/ha (MPP-EAS 1999). Bann (1999) carried out a study in Benut, Johor, and reported that the total economic value of mangrove was estimated at USD 8,916/ha. The nonuse (existence) value represents 84% of the total value. The local use benefits from protecting the site in terms of capture fisheries, tourism, and shoreline protections are estimated at USD 1,375/ha. Bennet and Reynolds (1993) conducted a case study on the economic value of the Sarawak Mangroves Forest Reserve. They found that the mangroves support marine fisheries worth USD 21.1 million per annum; up to 3,000 jobs; timber products worth USD 123,217 per annum; and a tourist industry worth USD 3.7 million per annum. The economic values of mangroves in Sabah are still unknown. Awang Noor (2005) reported various economic values for Matang Mangrove, Taiping, Perak based on various studies conducted in the area. The estimated economic values for various mangroves goods and services: timber (USD 62–644 per hectare), sustainable sport fishing (USD 352,631–526,316), capture fishery (USD 52.5 million per year), environmental and passive use values (USD 0.33–4.81 per household per year), cockle production (USD 8.5 million per year), and bird watching (USD 10–41 per trip).

Tangah (2005) pointed out that the current management practice for mangroves in Sabah focuses on regulating small-scale use of mangrove wood for building materials and for fuelwood for local consumption. The area is used for timber production and the conservation of the biodiversity of flora and fauna for the benefit of the local community. Timber production, such as the collection of poles and fuelwood, has been allowed up to a level that causes minimum disturbance to the ecosystem. A recent study by a group of researchers from Universiti Putra Malaysia (UPM) (using funding from the Ministry of Science, Technology

and Innovation [MOSTI]) determined the economic values of the mangrove forest ecosystem in Kota Marudu. This two-year project (2012–2013) attempted to determine the economic value of mangroves for timber, carbon sequestration, conservation value, fishery resources, non-timber forest products, and also the dependence of the local coastal community on the mangrove ecosystem for their livelihoods.

Communities living along the coast of Kota Marudu, Sabah are largely dependent on mangroves for their livelihoods. Other economic activities include agriculture and trading activities. The majority of coastal communities live below the poverty line. Poverty in Kota Marudu persists and the incidence of poverty here is one of the highest in Sabah (37.1%) (IDS 2007). Based on a UPM study, the average household monthly income is USD 296[1] (MYR 887) (range: USD 83 [MYR 250] – USD 1,833 [MYR 5,500]) (the poverty line in Sabah is USD 320 [MYR 960]). There are also environmental problems and threats to the mangrove ecosystem associated with anthropogenic activities. Anthropogenic threats to mangrove systems include pollution from development, charcoal production, and the overexploitation of resources. Natural threats to the mangrove ecosystem come from climate change, which would result in a rise in sea level that may affect the ecosystem and its biodiversity.

## The Views of the Minister

About 20 years ago, Kota Marudu and Pitas were underdeveloped, and the surrounding mangrove areas had been burdened with illegal logging activities that threatened and caused the disappearance of species such as the Proboscis monkey. Nonetheless, the ongoing restoration efforts (which began 15 years ago) and the proposed Tun Mustapha Marine Park have helped to reduce the illegal logging activities in the area. *The Star* (23 May, 2011) reported that on 22 May, 2011, the Minister urged people to protect the bay and to adhere to sound conservation practices to ensure the sustainability of marine resources. The Minister added that mangroves generate multiple ecosystem benefits and serve as nursery grounds for juvenile marine species. He also noted that subsistence fishing in the mangrove area is a main source of income for the local community due to the high planktonic biomass present in Marudu Bay. The Minister emphasized that studies need to be carried out to identify economic opportunities and potential threats to the ecosystem. He believes that ecotourism would help to protect and rehabilitate the mangrove ecosystems, as well as to encourage sustainable resource use. The Minister urged stakeholders to participate in the research and to have faith in the projects proposed by university researchers.

The Minister wants to explore the possibility of the development of ecotourism in Kota Marudu. The proposed ecotourism project should consider sound conservation practices to ensure the sustainability of mangrove and marine resources in the future. Considering the economic, employment, coastal protection, and species conservation values of mangroves, they should be well-managed; their importance should also be considered at all levels in development planning.

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[1] *USD 1.00 = MYR 3.00*

## Background

Kota Marudu is a small district located on the northern part of Borneo Island, Sabah, Malaysia. Kota Marudu is about 130 km (two-hour drive) from Kota Kinabalu. It is bordered by Kudat District on the northwest, Pitas on the northeast, Beluran on the southeast, and Kota Belud on the south. Kota Marudu can be divided into three distinct areas, namely, mountainous terrain, valleys, and the coast. Kota Marudu is located within Marudu Bay and is in the Coral Triangle Initiative (CTI) and the proposed Tun Mustapha marine protected area (MPA) (Figure 1). It occupies only 2.6% (19,197 km$^2$) of the total area of the state of Sabah. Access to Kota Marudu is via the Kota Kinabalu-Kudat main road. Kota Marudu has 13 zones, with 182 registered villages occupied by a population of 62,474 people. Kota Marudu town has commercial shops, small hotels, markets, and government offices; it is equipped with an infrastructure that includes schools, a clinic, and other basic facilities. Most of the population of Kota Marudu is involved in fishing (50%) and agriculture (30%), with any remaining population employed in various businesses and government sectors. Fishing-related activities include coastal fishing, fish farms, crab harvesting, oyster culture, and the collection of mangrove products such nipah leaves, nipah fruits, and mangrove wood.

**Figure 1. Mangrove forest in Kota Marudu**

## Mangroves in Kota Marudu

Kota Marudu has about 12,893 ha of mangrove forests, which have been gazetted as Class V (Protection) Mangrove Forest Reserves. The area is mainly used for conservation and for the protection of wildlife habitats, especially for migratory birds. About 70% of the area's coastal communities are largely dependent on fishery activities. The mangrove in the Kota Marudu area is very important for fishery ecosystem production as it provides food and other habitats for fishery and marine resources. Converting this area to other purposes will have negative impacts on mangrove and coastal ecosystems. As such, economic valuation of mangrove forests would provide information to policy makers on the trade-offs between mangrove conversion and development. This will eventually affect the long-term livelihoods of the coastal communities who depend on mangroves to sustain their livelihoods.

## Fishery Communities

There are 24 fishing villages in and around Kota Marudu. These villages are located in the area of Marudu Bay. The rich mangroves of Kota Marudu, which surround Marudu Bay, sustain the livelihood of more than 800 fishers engaged in traditional fishing. Most of these fishers have been engaged in this activity for generations (Fatimah et al. 2011). Marine capture fishery is the main activity for fishers in Kota Marudu and is traditional in nature. There are approximately 564 fishing boats, including boats for part-time fishing activities (Department of Fisheries 2007). Fishers use a variety of nets and traps to catch fish. Some of the fishers fish to sustain themselves and any remaining stock is sold to the local market. In 2010, 251.42 metric tons (t) of marine fish landed on Kota Marudu (Department of Fisheries 2010). This figure represents a contribution of about 0.1% to the total amount of marine fish landed in Sabah. Although its contribution to the amount of fish landed in the state is small, the fishing industry in Kota Marudu is significant to the coastal community that lives there. Marine culture (fish species include the sea bass, grouper, and mangrove snapper) is slowly gaining popularity for commercial purposes, which include floating cage systems and mollusk culture (for oysters). Fishermen are also provided with winches, fish nets, boats, engines, and fish seed via a fishery program. Although fishing is the major source of income within coastal communities, they are also involved in other agriculture-related activities that support their livelihoods.

## Biodiversity

Results from a UPM study showed that the primary mangrove colonist in Kota Marudu is *Rhizophora*. There are 16 species in 12 genera and 9 families within 1-ha (≥1 cm dbh). The largest family is represented by *Rhizophoraceae*, with five species that include *Rhizophora apiculata*, *R. mucronata, Bruguiera parviflora, B. gymnorrhiza,* and *Ceriops decandra*. The diversity of the mangrove forest in Kota Marudu is lower than that of the Matang Mangrove Forest in Peninsular Malaysia, which has 28 species in 15 genera and 12 families.

The Marudu Bay mangrove ecosystem is also vital for the survival of many resident birds. Their population relies on the dynamic nature of mangroves. For instance, the mangrove whistler (*Pachycephala grisola*) is virtually confined in mangrove areas. The destruction and fragmentation of mangrove forest, often due to land-based development, significantly reduces suitable habitats and threatens not only the survival of resident birds but other mangrove-dependent species as well. Some bird species have been recorded in Kota Marudu mangroves such as collard kingfisher, egret, little heron, stork-billed kingfisher, and striped tit-babbler.

## Ecotourism Development in Kota Marudu

### *Mangrove ecotourism opportunities in Kota Marudu*

Mangrove resources can be harnessed as potential drivers for new business opportunities to improve the standard of living through ecotourism activities. Ecotourism involves the application of the conservation of natural resources and the minimization of negative impacts on the environment as a result of tourism activities. Some business and economic opportunities for tourism products and services include special events, local skills and knowledge, local businesses, and intangible assets. Sustainable development programs designed to preserve the ecosystem of Marudu Bay use natural resources to improve people's livelihoods. Several business opportunities in Marudu Bay for ecotourism activities include homestays, aquaculture, sea cucumber and cage fishing, mangrove boardwalks, and observatories for birds. Efforts are being made to get local communities involved in ecotourism ventures and to attract investors to take up business opportunities in Marudu Bay, which would have positive knock-on effects in Kota Marudu.

Potential ecotourism projects that could be developed include the following:

***Special events.*** The annual Corn Festival takes place every November in Kota Marudu. Thousands of sweet corns and milk corns are grilled and distributed to visitors. People from surrounding districts such as Kudat, Kota Belud, and Pitas congregate in Kota Marudu to enjoy the grilled corn. Another important event, held every year in May, is the harvest festival, known as Pesta Kaamatan. During Pesta Kaamatan, Kota Marudu is alive with cultural activities that showcase different ethnic groups such as the Bajau, Suluk, and Dusun peoples. The Marudu Bay Carnival takes place in conjunction with Pesta Kaamatan and is normally organized in Kg. Tanjung Batu, which is about 20 km from Kota Marudu town. The carnival includes boat racing, a boat parade, a fishing competition, a regatta and a variety of water sports.

***Local skills and knowledge.*** Traditional skills include boat-making and making knives and machetes by hand from local wood and waste steel. Local people have inherited these skills from older members of the community; this, in turn, is passed down to their children. The skills associated with repairing fish nets are vital to the survival of most fishermen. Net repair work is normally undertaken by family members as a way to reduce costs and

keep as much income as possible within the family. Visitors can experience and learn new skills by participating in routine fishing activities.

***Local businesses.*** Sweet corn is a popular local snack, and it is sold at roadside stalls on the way to Kota Marudu. Fresh sweet corn cobs are grilled to perfection over a charcoal fire, giving a unique taste. Other local products, such as crafts and agricultural products, are also sold from sweet corn stalls.

***River cruises.*** There are many traditional fishing villages along the coast and beside major rivers such as at Kg. Tanjung Batu, Kg. Taritipan, Kg. Tambun, and Kg. Langkon. The traditional way of life followed by fishermen, including their interaction with the surrounding environment (with mangroves, rivers, and the bay), is in itself an ecotourism product. River cruises could provide visitors with a way of experiencing this unique way of life and also a way of enjoying the mangrove scenery. Visitors can also observe activities such as collecting mollusks and wild fruits.

## The Future of Ecotourism in Kota Marudu

Ecotourism infrastructures and facilities such as chalets and lodges should be designed to suit the surrounding landscape and climate. Buildings ought to be constructed using local materials and green technologies as much as possible for durability and comfort. These materials may include nipah for roofs and bamboo/wood for walls, beams, and flooring.

Ecotourism has the potential to benefit local people, especially those who have access to mangrove and coastal resources. Conservation measures and the good management of resources such as the surrounding environment itself, history and culture, special events, and intangible assets (local skills and knowledge, local community daily activities, etc.) is vital if this area is to be promoted as a potential ecotourism destination. Ecotourism needs to be well-planned and efficiently managed and promoted.

The local communities are aware of the vast potential that ecotourism can bring into their lives. They welcome assistance from both the government and the private sector to start their own ecotourism businesses or to be part of the workforce of ecotourism activities. Ecotourism is a good option for sustainable sources of income as it utilizes not only natural resources but the intangible assets that both the environment and local communities already possess.

A study of ecotourism activities that could be developed in Kota Marudu based on nonlocal respondents shows that about two-thirds of the nonlocal respondents are interested in boating, river cruising, visiting forest areas, fishing, wildlife and bird watching, and homestay programs. The average length of stay in Kota Marudu for ecotourism activities was found to be two days, and respondents stated that they would be willing to pay USD 150 for the two-day ecotourism activities. It is expected that ecotourism development in Kota Marudu would attract 10,000 visitors per year, and the trend will continue in the future. It is also assumed that the visitors will visit Kota Marudu one to two times per year.

However, there are some possible adverse environmental impacts as a result of ecotourism development in the area. The most significant impact is the degradation of river water quality. Ecotourism development will induce economic activities that may consequently increase solid waste, waste water, and other agro-based practices. As such, the level of siltation, influx of untreated sewage, and indiscriminate dumping of solid wastes, especially from the town center and also from agro-based activities, is expected to increase. There is no information about the environmental damages in the mangrove area of Kota Marudu.

## The Minister's Problem

The ecotourism development project would be implemented under the 11th Malaysia Plan in order to provide public amenities and basic infrastructure to catch up with development as well as to improve the standard of living of the local people. There are two possible options for the improvement of the standard of living in Kota Marudu:

1. Ecotourism development
2. Mangrove conservation

## Your Assignment

The Minister has contacted you to request assistance to address mangrove management and ecotourism development, including how best to implement ecotourism development that can improve the standard of living of coastal communities.

The Minister asks you the questions below.

1. What priorities should be set in order to lift the standard of living of coastal communities, and how might they be affected by programs to conserve the mangrove ecosystem?
2. How should the trade-offs between the proposed ecotourism project and mangrove conservation be compared? What are the environmental impacts that you need to consider when evaluating this trade-off?
3. What are the limits to economic activities within the mangrove ecosystem that can affect the long-term ecotourism development in the area?
4. What is the possible financial mechanism that can be implemented by the government to secure the provision of mangrove ecosystem services for ecotourism benefit?

The Minister is interested in your suggestions based on your response to the questions he posed to you.

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Namtok Mae Tear in Ob Luang National Park, Chiangmai, Thailand. Photo by ol'pete under creative commons license at www.flickr.com/photos/doiboipete/1784244864

# Save the Forest, the People, or Both? A Cost-Benefit Analysis of Resettlement Policy, Ob Luang National Park, Northern Thailand

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Based on EEPSEA Research Report No. 2003-RR10: *A cost-benefit analysis of resettlement policy: A case study of Ob Luang National Park, Northern Thailand* by Orapan Nabangchang

*This case study highlights the dilemma between the allocation of natural resources to satisfy social and economic objectives on one hand, and conservation objectives on the other hand. It is a story of conflict between two groups of people who share the same water sources. Although the context is watershed forests in Northern Thailand, similar situations can be found in other Southeast Asian countries where communities occupying areas upstream are often perceived to be the cause of changes in water supply and water quality downstream.*

*Case study users can be decision makers with mandates related to forestry, local government and nongovernmental organizations (NGO) working with local and ethnic minorities, and NGOs working on conservation issues. When using the case, each discussion group should include an environmental economist or an economist with a background in financial and economic analysis.*

*This case study can be used to encourage discussion about property rights, and how these can determine the ways in which people utilize resources, externalities, direct and indirect benefits from natural resources, and the social rate of time preference. This case study should demonstrate that economic analysis can contribute to finding options that generate the highest net social welfare as well as shed light on the distribution of costs and benefits.*

*Please note that the complexity of the issues discussed in this case study require a sound understanding of surrounding social, cultural, political, and legal dimensions.*

## Background

Ban Pa Kluay village is in the Chom Thong district of Chiang Mai province in the north of Thailand. The village is located in Ob Luang National Park, one of the country's last remaining areas of rich biodiversity. The history of the village dates back to 1975 when the Mobile Military Unit (MMU) moved five households into this forest to help trace the transportation

routes of illegal drug traffic between Thailand and Myanmar. In the years that have since passed, the then five households have expanded to 86 households. Since 1975, virgin forests have been cleared to bring land under cultivation. The village has also benefited from timber and non-timber forest products (NTFP) extracted from nearby forests.

Ban Pa Kluay is involved in a long-running conflict with villages located downstream. The villages downstream believe that Ban Pa Kluay's use of water upstream is the reason for the reduced water flow from the Mae Soi River, which is a major source of water for agriculture and domestic consumption. Although foresters and scientists are not convinced that farming activities at Ban Pa Kluay are entirely to blame, downstream communities have gathered to protect the Mae Soi watershed. Physical barriers have been put up around the watershed forests, trees have been replanted, and forest fire protection lines have been made. The level of discontent is so high that downstream communities demand that the villagers of Ban Pa Kluay be resettled elsewhere.

## Which Way Forward?

Under normal circumstances, the government would not consider Ban Pa Kluay to be any different from the 80,000 other communities living inside protected areas across Thailand. However, the government's term is coming to an end, and a new general election will take place in less than a year. The government wishes to avoid social conflict, especially as this particular province is a major political constituent.

The government sends a signal to the provincial governor to "do what it takes" to arrive at a solution that does not undermine the government's popularity. The government also specifies that the interests of all the stakeholders should be considered, and that the solutions identified should address pro-environment and pro-poor concerns.

The Governor calls a meeting of representatives of different groups as follows: (1) the Department of National Park Wildlife and Plants (DNP), which is responsible for protected areas; (2) NGOs that look out for the interests of ethnic hill tribes (hill tribe NGO) and therefore support the upstream community; (3) conservation NGOs who do not believe that communities can be settled within the protected area without adverse, irreversible environmental impacts; (4) local government units, who tend to support the downstream communities; and (5) the academe composed of forest experts, sociologists, legal experts, and environmental economists. This meeting produces three options.

***Option 1: Status Quo.*** This option leaves the situation as it is. Nothing will change and the inhabitants of Ban Pa Kluay will continue to use the forest as before. The proponents of this option believe that because there are existing laws, there is nothing more that DNP can do given the budget and manpower at their disposal. Advocates of this option also believe that this kind of situation has been an issue for several decades; with 80,000

similar settlements located inside protected areas, it is a national problem. Supporters of this option believe that no solution can be identified in less than 12 months.

***Option 2: Compromise.*** The compromise option is a middle-of-the-road solution. The principle of this option is to grant the villagers of Pa Kluay conditional rights to stay where they are, provided they enter into a partnership with local enforcement agents to patrol and protect the forest. Collecting forest products would not be permitted, but an area would be set up as a community forest. Additional occupational promotional measures would be provided to ensure that settlers are able to sustain their level of income from the land. This arrangement would entail financial and legal provisions for monitoring and protecting forest resources around the village.

***Option 3. Resettlement.*** This option proposes the resettlement of the villagers to a place outside the protected area. Action would have to be taken to provide the villagers with employment at their new location. Other measures would be needed to rehabilitate the degraded forests left behind and to prevent both the return of Ban Pa Kluay residents and encroachment by newcomers.

Aside from these three options, the stakeholders also share their different viewpoints.

1. The DNP representative points out that the Pa Kluay villagers have no legal right to be inside the protected area, and that they are violating the law by collecting timber and non-timber forest products. [Participants should concentrate their discussion on property rights]
2. The hill tribe NGO points out that although they have no private property rights, the villagers should at least have community rights to use land and forest resources as the earlier settlers were only there because the Mobile Military Unit put them there.
3. The conservation NGO notes that
    - Pa Kluay villagers are diverting the water into their fields, which means less water for communities located downstream. [Participants should concentrate their discussion on externality]
    - The villagers are using chemical fertilizers that wash into the stream and consequently contaminate the water, which was formerly used for domestic consumption. [Participants should concentrate their discussion on externality]
    - Pa Kluay villagers burn the forest in order to clear it for cultivation, which leads to the increased incidents of forest fires. [Participants should concentrate their discussion on externality]
    - All of these actions cost the downstream communities money, e.g. the cost of patrolling the forests, the cost of building forest fire protection lines, the cost of replanting and looking after saplings, and the cost of finding alternative sources of water. [Participants should concentrate their discussion on external costs and replacement costs]

## Your Assignment

The Governor is confused by the technical data and the different viewpoints presented by the expert sociologist, forester, agronomist, social anthropologist, and the representatives of NGOs and civil society. He knows that the interests of stakeholders such as the upstream community, the downstream community, and DNP must be considered because the present government cannot risk losing their political support. He also realizes that if Pa Kluay residents were to be moved, there would be costs associated with the procurement of land for resettlement and with finding new employment for the villagers because it would not be morally right to relocate them and not help them make this transition.

The Governor tasks you (as environmental economists) with digesting the information and analyzing which option is best. Use the above information and collect additional information regarding the costs and benefits of implementing each option. Because the earlier settlers were moved into the protected area by the Mobile Military Unit, make a judgment call and include compensation for the Pa Kluay villagers as a cost. Conduct the following sensitivity analysis:

1. Use different discount rates (i.e., 6%, 8%, and 12%) but decide to present only the results that use a 6% discount rate (Table 1).
2. Use different assumptions about including the value of carbon. This is because Thailand has very limited experience with both the regulatory and voluntary carbon market. Include and exclude the value of carbon. The timing of including value of carbon would be (a) no inclusion in the first five years, (b) no inclusion in the first 10 years, and (c) no inclusion in the first 15 years.
3. Use different assumptions about the effectiveness of the current efforts to control deforestation.
4. Use different assumptions about the time it would take to negotiate with the upstream communities about resettlement. The baseline assumes that negotiation would take 10 years, but analysis of the net present values (NPV) should also be conducted, which assumes that resettlement agreements can be reached more quickly (five years). You've done your calculations (Table 1 and Table 2).

**Table 1. Net present value of the three options**

| | Upstream | | | Downstream | | |
|---|---|---|---|---|---|---|
| | **Benefit** | **Cost** | **NET** | **Benefit** | **Cost** | **NET** |
| Status quo | 101,995 | 74,332 | 27,663 | 0 | 159,873 | –159,873 |
| Compromise | 47,720 | 43,812 | 3,908 | 247,103 | 39,596 | 207,507 |
| Resettlement | 67,226 | 50,893 | 16,333 | 53,668 | 111,029 | –57,361 |

**Table 2. Costs and benefits of the various options (in million THB)**

| Policy Options | Benefit | Cost | NPV |
|---|---|---|---|
| Base Case | | | |
| Base case: Status quo | 102.00 | 234.21 | –132.21 |
| Base case: Compromise | 294.82 | 83.41 | 211.42 |
| Base case: Resettlement | 229.54 | 162.92 | –42.03 |
| Excluding Carbon Value | | | |
| Status quo: Excluding carbon value | 102.00 | 132.45 | –30.46 |
| Compromise: Excluding carbon value | 198.48 | 78.00 | 120.47 |
| Resettlement: Excluding carbon value | 81.40 | 125.00 | –43.60 |
| Deforestation Controlled | | | |
| Status quo: Deforestation controlled | 93.99 | 91.52 | 2.47 |
| Compromise: Deforestation controlled | 78.92 | 72.73 | 6.20 |
| Resettlement: Deforestation controlled | 82.26 | 107.32 | –16.09 |
| Excluding Carbon Storage Value Years 1–5 | | | |
| Status quo: Excluding carbon storage value Years 1–5 | 102.00 | 221.68 | –119.69 |
| Compromise: Excluding carbon storage value Years 1–5 | 287.71 | 78.00 | 209.70 |
| Resettlement: Excluding carbon storage value Years 1–5 | 112.77 | 150.58 | –37.82 |
| Excluding Carbon Storage Value Year 1–10 | | | |
| Status quo: Excluding carbon storage value Years 1–10 | 102.00 | 196.10 | –94.11 |
| Compromise: Excluding carbon storage value Years 1–10 | 262.12 | 78.00 | 184.12 |
| Resettlement: Excluding carbon storage value Years 1–10 | 118.90 | 125.00 | –6.10 |
| Excluding Carbon Storage Value Years 1–15 | | | |
| Status quo: Excluding carbon storage value Years 1–15 | 102.00 | 164.86 | –62.86 |
| Compromise: Excluding carbon storage value Years 1–15 | 230.88 | 78.00 | 152.88 |
| Resettlement: Excluding carbon storage value Years 1–15 | 102.92 | 125.00 | –22.07 |

*Table 2 continued*

| Policy Options | Benefit | Cost | NPV |
|---|---|---|---|
| Excluding Carbon Storage Value Years 1–15 | | | |
| Resettlement delay 5 years | 223.02 | 142.70 | 80.31 |
| Resettlement delay 15 years | 97.66 | 97.85 | –194.23 |

*Notes:* (1) NPVs are at 6% discount rate. (2) Benefits from the compromise scenario would not be realized until Year 4. (3) Benefits from the resettlement option would not be realized until Year 11.

Now, present your results to the stakeholders, stating the best option from an economic efficiency point of view. After presenting your results, your analysis is challenged by the stakeholders, as summarized below.

1. ***NGO:*** Will your results pass the test of equity considerations? The upstream community cannot entirely be blamed because it was the MMU that brought them to settle the area in the first place. [Participants should concentrate their discussion on equity issues: distribution of costs and benefits]
2. ***Fellow economist:*** Why is a low discount rate used? [Participants should concentrate their discussion on social rate of time preference]
3. ***Provincial governor:*** Many things remain uncertain, such as whether or not we can sell carbon credit or how long it will take to get an agreement about resettlement. Moreover, DNP might become more efficient in the future with regard to controlling deforestation. How can all these uncertainties be taken into consideration? [Participants should concentrate their discussion on sensitivity analysis]

   Politically, it may be sensitive to compensate the Pa Kluay villagers. [Participants should concentrate their discussion on property rights]
4. ***Legal expert:*** Why compensate the Pa Kluay villagers when their use of land and forest resources is actually violating the law? (which clearly states that in a protected area such as Ob Luang National Park, economic activity is strictly forbidden).
5. ***NGO:*** We disagree with the legal expert and agree with the principle of compensating the Pa Kluay villagers. On the issue of access to natural resources, however, the legal expert is not considering the fact that the Pa Kluay villagers have been benefiting from forest resources for a long time; thus, they have some informal rights to resources.

6. ***DNP representative:*** The benefits of the forest are not just the timber and NTFPs; it also provides a habitat and carbon sequestration function. How can these factors be taken into consideration? [Participants should concentrate their discussion on indirect benefits]

   How can the benefits of having forest coverage (e.g., protecting the top soil, reducing the risk of flash floods, providing an important wildlife habitat) be taken into consideration? [Participants should concentrate their discussion on the nonmarket valuation of indirect use value and nonuse values]

Review these points. Do they invalidate your results? How can your analysis be enriched to accommodate these other dimensions of the issue?

*"Maximus"* is one of the tallest and oldest elephants at the Elephant Nature Foundation. This giant was once struck by a car that caused a permanent damage to its hind legs. Photo by Robbi Baba under creative commons license at www.flickr.com/photos/robbibaba/3262382846

# To Kill or not to Kill Elephants? Converting Human-Elephant Conflict into Human-Elephant Harmony

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Based on EEPSEA Research Report No. 2011-RR14: *Analysis of policy options to convert human-elephant conflict into human-elephant harmony* by Rawadee Jarungrattanapong and Siriporn Sajjanand

*This case study highlights the problem of limited food and water resources in some elephant sanctuaries. This leads elephants living in protected areas to venture into surrounding croplands to search for food. Crop-raiding by elephants causes damage to crops and property and also injury and loss of life to both humans and elephants. This problem is known as human-elephant conflict (HEC) and is happening in several parts of the world, including South Asia and Africa.*

*The target audience for this case study is decision makers, e.g., Minister of Natural Resources and Environment, local government officers, and nongovernmental organizations (NGO) working in wildlife conservation, as well as students interested in natural resources issues. The case study can be used to encourage audiences to discuss policy options and their application to HEC. The case study provides some information on the impacts of HEC and proposes mitigation options to help case study users understand the problem. The target audience should have some background in economics, particularly cost-benefit analysis (CBA), and an awareness of budget limitations, social acceptance, and ethical constraints. Audiences need to prioritize the proposed mitigation options and explain which criteria they use to rank policy options.*

## Introduction

The Asian elephant (*Elephasmaximus*) has been revered and has been used as a warrior and even as a cultural ambassador (WWF 2008). The Asian elephant is also classified as an endangered species by the International Union for Conservation of Nature and Natural Resources (IUCN). Elephants are of cultural importance to Thai society such that a white elephant used to be placed at the heart of the National Thai flag. Under Thai legislation, wild elephants are protected by the National Park Act (1961) and by the Wild Animal Reservation and Protection Act (1960). The number of elephants in Thailand has been decreasing, except for those in some protected areas (e.g., Khao Ang Rue Nai [KARN] Wildlife Sanctuary) where local predators are now extinct; in KARN the elephant population cannot be controlled.

Some protected areas have limited food and water resources for elephants. This leads to elephants venturing outside their sanctuaries into villages, which results in HEC. Sometimes, the elephants in KARN block trucks carrying sugarcane in order to eat the sugarcane; the villagers called these elephants "sugarcane robbers." HEC not only causes damages to crops and property but also injury and loss of human and elephant life. In 2010, two men were found dead and one man was injured as a result of HEC. Mrs. Malee's 30-year-old son was one of these HEC victims—he was stabbed by an elephant's tusk while he guarded his crop through the night.

The KARN wildlife sanctuary has experienced HEC. KARN is one of seven protected areas in Thailand that harbor more than 100 elephants. KARN is also one of the 24 protected areas that demonstrate the most severe level of HEC in Thailand (Wanghongsa, Boonkird, and Boonkird 2008). The KARN wildlife sanctuary covers an area of 1,079 square kilometers ($km^2$) of lowland rainforests across five provinces (Chachoengsao, Chonburi, Rayong, Chanthaburi, and Sakaew) (Figure 1). The study of Jarungrattanapong and Sajjanand (2011) reported that the average HEC cost borne by households (e.g., crop loss, mitigation costs, and the opportunity cost of time spent guarding crops) in KARN is THB 48,374 per household per year or USD 1,612 per household per year, which accounts for 26% of a family's annual household income. In the study, villagers affected by crop-raiding elephants have applied traditional methods—the aim being to chase the elephants away. Examples of traditional measures include using firecrackers and hand-made lamps to scare the elephants, simple electric fences to keep them out, and elevated huts to keep watch over farmland.

Some local government agencies believe that translocation is the best solution to the HEC problem. However, NGOs disagree with this idea because the elephants would have to endure a stressful period of imprisonment in vehicles during transportation; there have been several cases where elephants have died from injuries sustained in this process. Some experts suggest

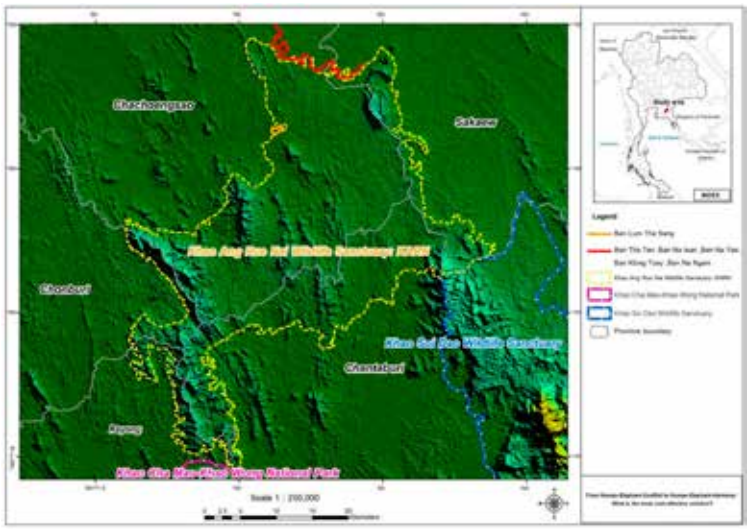


**Figure 1. KARN wildlife sanctuary**

that compensating the affected households would be a proper solution; however, the government faces budget constraints. The Ministry of Natural Resources and Environment and local government offices have tried to alleviate the HEC problem by putting mitigation measures in place, but these measures have failed to eliminate the problem. Examples of mitigation measures include habitat-improvement activities (increasing water resources and installing mineral licks) and digging ditches that elephants cannot cross (Figure 2).

Increasing the amount of water resources | Increasing the number of mineral licks | A pilot ditch

**Figure 2. HEC mitigation measures undertaken by government agencies**

## Looking at Policy Alternatives

### *Habitat improvement*

Wildlife experts suggest that habitat improvement in KARN could make it more hospitable to the elephants. The strategy would be to remove any incentive for the elephants to leave the protected area by enabling them to sustain life without raiding farms for food. The proposed measures include increasing the number of water resources, mineral licks, and grassland. Grassland coverage could be increased by replacing alien species with native species of grass—this area would have to be reconverted to grassland every 10 years because invasive alien species would recover the area in that period of time. The costs of habitat improvement in KARN are shown in Table 1.

**Table 1. Costs of habitat improvement in KARN**

| Activities (Unit) | Cost per Unit |
|---|---|
| Ponds (pond) | THB 50,000 (USD 1,667) |
| Mineral licks (mineral lick) | THB 2,500 (USD 83) |
| Conversion of invasive alien plants to grassland (rai) | THB 1,060 (USD 22,083/km$^2$) |
| Planting supplementary food for elephants (rai) | THB 2,500 (USD 52,083/km$^2$) |

*Source:* Jarungrattanapong and Sajjanand (2011)
*Notes:* (1) All values are in 2010 prices. (2) rai = 1,600 m$^2$

### *Supplementary feeding*

The idea of this measure is to deposit food that elephants eat, such as sugarcane, in areas where crop-raiding is a problem, thereby attracting elephants and keeping them in their designated areas. However, this problem will recur if the practice is discontinued or the supplementary food provided is not sufficient.

### *Contraception for female elephants*

Birth control for female elephants should be introduced when the elephant population exceeds the maximum capacity (e.g., the maximum capacity of KARN is 500 elephants). The cost of contraception for female elephants in KARN is approximately THB 50,000 (USD 1,667) per elephant. This contraception needs to be reintroduced every 10 years.

### *Land-use changes*

Land-use planning to deal with HEC is a long-term process that needs government support. Legislative and/or policy changes are expensive options but their long-term benefits include HEC alleviation, habitat improvement for other species, and newly positive relationships between elephants and local people (Nelson, Bidwell, and Sillero-Zubiri 2003). However, this measure requires cooperation from local villagers—if they do not agree with the measures, then it is difficult to implement them.

### *Elephant barriers*

An elephant barrier or physical barrier is an obstruction constructed to prevent elephants from coming into crop fields or villages or to contain elephants in a particular area (e.g., a protected area) (Fernando et al. 2008). Elephant barriers are often seen as the enduring solution in HEC, and they are usually built where conflict is severe (Nelson, Bidwell, and Sillero-Zubiri 2003). There are several forms of elephant barrier, such as ditches, unelectrified fences, stone walls, buffer crops, and electric fences; different elephant barriers are appropriate to specific environments. For example, the effectiveness of ditches is increased by erosion-resistant soil, vegetative groundcover and regular maintenance (Nelson, Bidwell, and Sillero-Zubiri 2003). However, elephants can fill-in ditches by kicking in the sides, and then simply walk across them (Perera 2009). Unelectrified fences constructed from regular fencing materials (wire and concrete or wooden posts) are sufficient deterrents if elephants are not persistent raiders (Nelson, Bidwell, and Sillero-Zubiri 2003). Electric fences are perceived to be the most successful barrier against elephant raiding if they are properly maintained and are accompanied by extreme measures such as shooting elephants (Fernando et al. 2008; Nelson, Bidwell and Sillero-Zubiri 2003).

### *Translocation*

Two criteria are used to select elephants for translocation: (1) habitual fence breakers and (2) discrete family groups in small units that can be relocated all at once (Omondi et al. 2002). Theoretically, translocation provides a straightforward solution; however, translocation requires a high degree of expertise and logistic capability (Perera 2009) such as preliminary studies of the social structure of the elephants, whether the whole herd can/should be moved or only problem males moved (Nelson, Bidwell, and Sillero-Zubiri 2003). Furthermore, capturing and transporting elephants require several activities that include identifying a particular individual, followed by capture, restraint, transport, and release (Fernando et al. 2008). In several cases, elephants have died from injuries sustained during capture. For example, during a translocation from Sweetwaters Rhino Sanctuary to Meru National Park in Kenya (Omondi et al. 2002), 56 elephants (nine individual bulls and nine family groups) were translocated during 12 capture operations carried out over 22 days. Five elephants died during the capture process and four elephants died during transportation.

### *Killing elephants*

In India and Sri Lanka, hundreds of raiding elephants, mostly adult males, are killed annually by farmers, even though killing elephants is a highly controversial, emotive issue, and is unacceptable in the cultural context of Asian countries (Fernando et al. 2008; Perera 2009). Killing those problem elephants also takes place in Africa (Hoare 1995). The advantage of this method is that it is a relatively cheap quick-fix solution that provides an extra supply of free meat for local people (Nelson, Bidwell, and Sillero-Zubiri 2003; Hoare 2001). Nevertheless, problematic elephant behavior still exists, even when culprit individuals have been eliminated from these populations for decades, because other elephants replace them (Hoare 2001; de Boer and Ntumi 2001; Perera 2009).

### *Compensation*

In theory, compensation at the proper level should completely eliminate the economic loss caused by HEC. However, in practice, farmers tend to overclaim compensation (Fernando et al. 2008) and reduce their efforts to prevent the damage caused by elephants (called "perverse incentive").

## EEPSEA Research Report

The research report funded by the Economy and Environment Program for Southeast Asia where this case study is based on used CBA to analyze the combination of measures that should help to alleviate the HEC problem in KARN wildlife sanctuary over a 20-year

period (Jarungrattanapong and Sajjanand 2011). The options considered were (1) habitat improvement and female elephant contraception; (2) habitat improvement, female contraception, and land-use change; and (3) habitat improvement, female elephant contraception, and electric fences. Policy Option 3 showed the highest net present values and was also the most cost-effective option (Table 2).

## Your Assignment

The Minister of Natural Resources and Environment asks the Thailand Development Research Institute (TDRI), a well-respected Thai think tank, for guidance on Thailand's HEC problem. You are a TDRI researcher with experience in natural resource management. Your assignment is to prepare key messages regarding measures to improve HEC for the Minister of Natural Resources and Environment. The proposed measures can be a combination of policies but you must take different aspects of the problem into consideration (e.g., budget limitations, degrees of social acceptance, and ethical constraints). You need to prepare key messages for the Minister on the following questions:

1. How should the list of proposed measures to mitigate the HEC problem be prioritized?
2. What criteria should be used to choose between the options?
3. Do you think killing elephants is a proper solution to the HEC problem in Thailand?

**Table 2. NPVs of the net benefits of the three policy options (in million THB/million USD)**

| Scenarios | Discount Rate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3% | | | 5% | | | 8% | | |
| | Growth Rate of Crop-Raiding Cost | | | Growth Rate of Crop-Raiding Cost | | | Growth Rate of Crop-Raiding Cost | | |
| | 5% | 10% | 15% | 5% | 10% | 15% | 5% | 10% | 15% |
| Status quo | –582.5 | –786.9 | –1,160.2 | –489.4 | –646.4 | –928.9 | –387.6 | –495.8 | –685.7 |
| | (–19.4) | (–26.2) | (–38.7) | (–16.3) | (–21.5) | (–30.9) | (–12.9) | (–16.5) | (–22.9) |
| Policy 1: Habitat improvement and contraception | –32.2 | 97.8 | 373.9 | –31.6 | 65.6 | 270.2 | –30.0 | 34.0 | 167.0 |
| | (–1.1) | (3.3) | (12.5) | (–1.1) | (2.2) | (9.0) | (–1.0) | (1.1) | (5.6) |
| Policy 2: Habitat improvement, contraception, and land-use change | –915.3 | –710.8 | –337.6 | –788.3 | –631.2 | –348.8 | –646.2 | –538.0 | –348.1 |
| | (–30.5) | (–23.7) | (–11.1) | (–26.3) | (–21.0) | (–11.6) | (–21.5) | (–17.9) | (–11.6) |
| Policy 3: Habitat improvement, contraception, and electric fences | 64.0 | 253.5 | 607.3 | 43.6 | 188.7 | 455.6 | 22.5 | 121.9 | 300.4 |
| | (2.1) | (8.4) | (20.2) | (1.5) | (6.3) | (15.2) | (0.7) | (4.1) | (10.0) |

*Source:* Jarungrattanapong and Sajjanand (2011)
*Note:* (1) USD 1 = THB 30 (2) Figures in ( ) are the USD equivalent.

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A Yellowfin Tuna fisherman in Mindoro, Philippines. Photo by Gregg Tan

# 2

# Saving Coastal Fishery Ecosystems


*"Bantay Dagat"*, the Sea Patrol, enforces fisheries laws in Misamis Occidental, making sure that fishers keep within the rules and regulations mandated by the local government units governing Iligan Bay, Philippines. Photo by Idohna Leah Buendia of WorldFish.

# Fish Kill due to the Mismanagement of Aquaculture: A Teaching Case

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Based on the EEPSEA Technical Report: *Pollution-induced fish kills in Bolinao: Effects of excessive aquaculture structures and overstocking* by Zenaida M. Sumalde, Karen Lou A. Francisco, and Mildren Peñales

*This case study illustrates the issue of fish kill, which is associated with mismanaged aquaculture in the Philippines. This case also presents data on the importance of aquaculture to the economy, the problems associated with aquaculture, and occurrences of fish kill in selected aquaculture areas in the Philippines. Likewise, the non-enforcement of local government ordinances related to the industry due to the conflict of interest displayed by local officials, who can also be aquaculture operators, is discussed. The issues in this case study may be applicable to aquaculture in other countries as well.*

*This case study is intended for use by policy makers and/or fishery managers when discussing what steps should be taken to regulate the aquaculture industry and prevent future catastrophic fish kill. It can also be used by teachers of natural resource and environmental economics as case material that can enable students to exercise critical thinking on how to integrate their knowledge on natural resource use and on the application of market-based instruments for dealing with environmental pollution. General knowledge about trade-off and marginal analysis is necessary.*

*The case study should be used to encourage discussion about the criteria for choosing alternatives or options related to resource conservation and environmental pollution. Thus, the case study can illustrate how economic analysis can be used to determine the distributional impact of policy options and the political economy of resource use and management.*

## Introduction

According to the Food and Agriculture Organization (2006), half of the world's fish consumption is farmed rather than caught in the wild because of stock depletion in marine fishery. As a result of overfishing, commercial and coastal fishing has suffered a decline in production over time. As such, aquaculture has grown rapidly—by about 10% per year during the 1950s and 1960s, by 9% during the 1970s and 1980s, and by 11% since the 1990s (FAO 2005).

In the Philippines, fishery is a net exporting sector, boasting USD 417 million of foreign exchange earnings in 2007. Aside from being a major export product, the fishery sector provides an important source of animal protein, contributing as much as 70% of the animal protein consumed by Filipinos, especially in low-income households (Dey and Ahmed 2005; Garcia, Dey, and Navarez 2005).

Within the country's fishery sector, aquaculture is the largest subsector, contributing 48% to the total volume of fishery production. This amounts to 2.4 million metric tons (t) of fish valued at PHP 73,724 billion in 2008. As in most Asian countries, the contribution of aquaculture to total fishery production in the Philippines increased rapidly from 1997 to 2008, turning it into a significant food production sector with a mean growth rate of 8.6% per annum (Garcia and Sumalde 2013).

However, the economic contribution of the aquaculture subsector is greatly threatened by unsustainable practices. Mismanagement has led to fish kill, which negatively affects economic gains made from aquaculture farming. Moreover, fish kill also affects aquaculture operators within the affected area because fish kill lowers consumer demand for fish for several weeks (because of the fear that dead fish are still being sold in the market). This drop in consumer demand affects the market price of the commodity, thereby affecting the income of aquaculture producers in other areas. In addition, fish in the wild are affected and small fishers end up with a very small catch or no catch at all. These direct and indirect losses demand an immediate government response to ensure that one of the most promising sectors in the country does not become unsustainable.

## Aquaculture and its Management in the Philippines

Traditionally, aquaculture species are grown extensively in ponds. However, due to the increasing demand for aquaculture and because of the prohibition of cutting mangroves for aquaculture production (early 1990s), aquaculture shifted to intensive cultivation that entails constructing fish pens and fish cages in coastal waters and rivers.

The four leading aquaculture species in the Philippines include seaweeds, milkfish, tilapia, and tiger prawn. Milkfish and tilapia are the most popular aquaculture food species due to their affordability compared to tiger prawns. These species take the highest shares of aquaculture, accounting for 47% (milkfish) and 35% (tilapia) of total aquaculture production (BAS 2008).

The government agency responsible for regulating the fishery sector in the Philippines is the Bureau of Fisheries and Aquatic Resources (BFAR) of the Department of Agriculture (DA).

When Republic Act 7160 (also known as the Local Government Code of the Philippines of 1991) was passed, the functions of national government agencies, including those related to fisheries, were devolved to the local government from the provincial level down to the *barangay* (village) level. Thus, local government units (LGU) are now responsible for regulating the aquaculture sector.

To protect the aquaculture industry, LGUs formulate and issue several municipal ordinances (MO) under the Municipal Development Plan (MDP). The MOs indicate the limit on the number of aquaculture structures that can be constructed along municipal coasts and the number of fish pens and fish cages that an operator can own. There are also BFAR recommendations on the appropriate aquaculture management practices including the sizes of fish pens and fish cages, stocking density, quantities of commercial feeds, and the frequency of feeding species. Water-quality monitoring is also supposed to be conducted in municipal waters to make sure that water quality is conducive for fish growth.

## Fish Kill and its Causes

However, despite LGU ordinances and BFAR administrative orders, mismanagement by aquaculture operators still takes place. There are reports of high numbers of fish pens and fish cages that exceed the carrying capacity of the water bodies they occupy. In order to increase the harvest, operators also stock fish beyond the recommended number of fish per area and feed them beyond the optimal recommendation. The caretakers of the fish pens and fish cages report that fish are fed continuously, especially during the month before they are to be harvested (Sumalde, Francisco, and Peñales 2003). This overfeeding leads to waste, especially during cold weather when fish do not need to eat as much.

Consequently, these practices contribute to the occurrences of fish kill in aquaculture areas. For example, in Bolinao, the recorded number of permits issued by the Coastal Resource Management Office (CRMO) of LGUs in 1999 was 476 units; but a visual inspection conducted by the Marine Fisheries Resource Management Program (MFRMP) revealed that the actual number of aquaculture structures was 797 units, which is well beyond the 544-unit capacity of the area (Table 1). The data showed that there is an excessive number of structures in Bolinao. In addition, the milkfish frys are also stocked at 15–50 frys per square meter (fry/$m^2$), which is intensively high compared to the recommended stocking density of 12–15 frys/$m^2$.

**Table 1. Number of aquaculture structures in Bolinao, 1995–2002**

| Year | Number of Structures |
|---|---|
| 1995 [a] | 242 |
| 1997 [a] | 1,076 (visual survey); 703 (permits officially issued) |
| 1998 [a] | 476 (permits officially issued) |
| 1999 [b] | 797 (visual survey) |
| 2000 | 993[c] (MFRMP, 2000); 371 (permits officially issued) |
| 2001 [b] | 1,170 (AFMA-DMEQCMA study) |
| January 2002 | 1,067 (LGCAMC physical count); 621 (permits officially issued) |

*Sources:* [a] Verceles, Macmanus, and Aliño (2000); [b] MFRMP; [c] AFMA-DMEQCMA; [d] CRM office, Bolinao

In fact, fish kill has occurred in these aquaculture areas but were considered minor by the fishers and operators, who continued their unsustainable practices. Serious fish kill then ensued. Records of the worst fish kill are as follows:

- 1–3 February 2002, Bolinao, Pangasinan = milkfish valued at PHP 600 million, worst fish kill recorded in the country;
- 2008, Taal Lake[1] = 50 t of tilapia and milkfish valued at PHP 4 million;
- 28–29 May 2011, Taal Lake = 750 t milkfish valued at PHP 63.70 million; and
- 30 May 2011, Anda, Pangasinan = 500 t of fish valued at PHP 57.50 million.

Operators blame climate change for the fish kill; however, water-quality testing results point to low dissolved oxygen (DO) and overcrowding as the contributory causes of fish kill. This is supported by a study by Sumalde, Francisco, and Peñales (2003), which indicates an inverse relationship between aquaculture production and water quality and stocking density. A water-quality testing conducted by BFAR a few days before and during the fish kills in Bolinao pointed out that the DO level was only 1.5 parts per million (ppm)—way below the recommended level of 5 ppm for fish growth. A low DO level can suffocate gill-breathing organisms, and is one of the most common causes of fish kill. Moreover, BFAR also reported that hydrogen sulfide is high in aquaculture areas during fish kill. This toxic gas is caused by amino acids in the uneaten/leftover fish feed that settles at the bottom of fish cages and fish pens. Operators had been warned of these indicators, but many still restocked their fish cages and pens; most of the newly stocked milkfish died.

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[1] *Taal Lake has an estimated carrying capacity of 6,000 units of milkfish and tilapia fish cages, but unofficial data from the municipal agriculture office show that the number of aquaculture units present in the lake in 2009 was almost double this capacity.*

## The Problem

Several recommendations have been forwarded in response to the fish kill events. One of the mayors in the affected aquaculture areas declared that MOs included in the MDP should be strictly enforced and that fish pens should be demolished, leaving only fish cages. Thus, the unconsumed feed and waste that settles at the bottom of a fish pen cannot be removed, causing eutrophication that contributes to fish kill. However, unofficial reports indicate that, in some areas, fish pens and fish cages are owned by local officials.

Some experts recommend implementing a moratorium on aquaculture for a while to give water bodies time to recover. This course of action is supported by BFAR, who further recommended demolishing fish cages. In fact, during the fish kill event in Pangasinan in 2011, BFAR demolished the fish pens where the fish kill had occurred to prevent fish kill in nearby waters. There were objections to these actions because many people derive livelihood from aquaculture. In addition, a moratorium on and the demolition of aquaculture structures would have serious consequences on food and nutrition security.

A month after the worst recorded fish kill in 2002, Senate resolutions urged the Senate Committee on Local Government to conduct an inquiry into this event in order to aid the creation of appropriate legislation. The intent was to introduce remedial measures and to prevent another disastrous fish kill event in the country. However, to date, no concrete legislative action has been passed by the Senate, or even an administrative order issued by BFAR, to address the fish kill issue.

On a more optimistic note, the most recent breakthrough related to fish kill is the development of IT technology that can detect the possibility of a fish kill event several days before it happens. This technology has been piloted in Taal Lake by a team of scientists from the University of the Philippines Los Baños and the staff of BFAR Region IV-A. The technology has been demonstrated to be effective. Recommendations regarding the adoption of the technology have been submitted to LGUs through the Municipal Agriculture Offices of the aquaculture municipalities in Batangas. However, the technology has not been adopted by aquaculture operators.

In light of the continuing problems related to fish kill, BFAR needs recommendations on what to do. Below are some of the options that could be undertaken.

1. *Do nothing.* Let the aquaculture operators reap the consequence of their practices. If this is done, the likelihood that fish kill will occur is high, and this may have catastrophic consequences not only on the fishery sector and the economy but on the environment as a whole. In normal circumstances, the net income from 4,000 square meters ($m^2$) of aquaculture amounts to PHP 309,969 (based on 2001 costs and returns data).

2. *BFAR, together with LGUs, could push for a moratorium on aquaculture operations for two production cycles as recommended by experts.* If this action was to be implemented, there would be a shortage of fish, the price of fish and fish substitutes would increase, and workers employed in the aquaculture sector would be displaced. One aquaculture structure (a fish cage) measures 40 m x 100 m. A 4,000 $m^2$ area of aquaculture usually employs one permanent worker and two part-time workers during harvest time. On the average, an aquaculture operator in Bolinao owns 6 units (but operators can run as few as 1 unit and as many as 11 units) of aquaculture structure.
3. *The fishers associations, through the Partylist representing the fishery group, could push Congress and the Senate to legislate fishery regulations about incentives for good aquaculture practices and penalties for violators.* The fishers have a representative group in Congress but it would take time for the legislation to be passed (normally, it takes at least two years, depending on the aggressiveness of the proponent). Also, what else should be done to enforce the regulation if it is not already enforced at the municipal level of government? Should a higher authority enforce regulation and then decide on the penalties for violators?
4. *BFAR could compel aquaculture operators to adopt the early warning device that can detect an occurrence of fish kill several days before it happens.* This device has been tested for effectiveness but information on the cost of adopting the technology and the mechanism by which it could be provided to the operators is not yet available.
5. *Market-based instruments, such as tradeable/transferable permits (TP) or subsidies, could be imposed.* How would the number of TPs be determined, and what would be the mechanism for distribution?

## Your Assignment

1. Discuss the case study as it has been presented, and decide which of the options you would recommend.
2. In your recommendation, make sure that you state your assumptions and give strong justifications for the option(s) that you favor.
3. What criteria will you use to identify the options you recommend?
4. Remember to discuss the short-term and long-term advantages and disadvantages of each option.
5. Expand each option or add other option(s) you think appropriate.

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Songkhla Lake, Southern Thailand. Photo by Kunlayanee Pornpinatepong

# Saving Songkhla Lake: Can Market Mechanisms Work?

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Based on EEPSEA Research Report No. 2010-RR5: *Pollution control and sustainable fisheries management in Songkhla Lake, Thailand* by Kunlayanee Pornpinatepong, Sakchai Kiripat, Sinad Treewanchai, Sukampon Chongwilaikasaem, Chotima Pornsawang, Pathomwat Chantarasap, Chantip Chandee, and Pornchanok Jantrakul

*This case study is about the severe decreases in fishery production due to water degradation in Songkhla Lake, Southern Thailand. Case study users will be asked to do the following: (1) identify the advantages and disadvantages of command-and-control vs market-based systems; (2) consider and select a set of criteria from the given information in order to assess, prioritize, and select management policy options; and (3) identify the additional information or research studies needed to support the selected management policy.*

*The target users of this case study are decision makers with mandates related to lake management, local government employees, community leaders, and nongovernmental organizations (NGO) working on conservation issues. This case study can also be used to teach students via problem-based learning. Teaching staff can use this case study to encourage students to discuss property rights, externalities, and the direct and indirect benefits of the lake system.*

*Each discussion group using the case study should include environmental economists or economists with a background in market-based policy.*

## Southern Songkhla Lake

Southern Songkhla Lake, known locally as Thale Sap Songkhla or simply Southern Lake, is one of the three interconnected lakes that form Songkhla Lake. Songkhla Lake is located in Songkhla province, on the southeast coast of Thailand, and covers an area of about 180 square kilometers.

Southern Lake empties into the Gulf of Thailand through a small channel, which also serves as the harbor entrance to the town of Songkhla. The lake has a season-dependent salinity—its water is brackish to salty during the dry season (February–April) when freshwater input is minimal; it is mostly fresh during the wet season from November to March when freshwater input is high.

The lake plays a unique role in the environment because it acts as the lungs for the inland harbor at the town of Songkhla. Due to tidal currents, the depth of the harbor and its channel are maintained at 6–8 meters. Seasonal fluctuations in the water level of the lakes wash away new sediment and remove isolated patches of water hyacinth after the plants have died because of the saline water.

The current open lagoon is essential to all forms of aquatic life in the lakes because open water, wind, and waves effectively put oxygen into the water. An open lagoon with an undisturbed circulation of fresh and brackish-water is a prerequisite for a stable and healthy ecosystem. Any change in the quality of the water, whether from natural or man-made intervention, is likely to affect the whole system.

## Decreasing Fishery Production

Southern Lake has always been rich in fishery resources, and fishing is the major occupation in the area. People also collect forest products and cultivate food crops such as rice and fruit. These natural resources are the main sources of livelihood and food for the many small communities around Southern Lake. Approximately 800,000 people live around the lake and 9 of the 16 districts of Songkhla province border the lake.

The catchment areas of Southern Lake are mostly located in Songkhla province, so the province's economy is interconnected with the lake's fishery and agricultural production activities. In recent years, the fishery sector's economic contribution to the province has decreased while those of most other sectors has increased (NESDB 2006).

Shrimp fishing is the most profitable economic activity in Southern Lake. On the average, the income from the shrimp catch is almost 10 times that of any other catch. Presently, however, the shrimp catch in Southern Lake has decreased significantly in terms of both the amount landed and the variety of species encountered. Sirimontaporn, Choonhapran, and Tansakul (1999) reported that there had been 30 species of shrimp in Songkhla Lake in the early 1980s (most of which were in Southern Lake), but a study in 2002 found only 11 species present (Mabuntham 2002). A related study found that the shrimp catch from standing traps, the most common local fishing trap, decreased from 3.6 kilograms (kg) a day in 1996 to 0.9 kg a day in 2003 (ONEP 2004).

## Problems and Causes of Decreasing Fishery Production

Songkhla Lake is facing serious water pollution due to human activities and industrial development. In 2001, domestic wastewater (from Hat Yai city, the most populous and largest business center of the Songkhla Lake basin) containing 3,375 kg BOD (biological oxygen demand) was being discharged into the lake every day. Pesticides and fertilizers from agricultural activities, nutrients from shrimp farming and livestock waste, oil and grease from shipping, and other activities in the harbor have also accumulated in the lake (ONEP 2004). The direct impacts of these pollutants on the fishing industry increase year by year.

In 2005, the Department of Pollution Control reported that there had been 1,567 factories around Songkhla Lake. Half of these were large factories, running equipment of more than 50 horsepower. About 63% of these factories were centered around Southern Lake, with their accumulated discharge having serious detrimental impacts on the water quality. Recently, industrial activities that were encouraged by government policy have increased alongside the growing population. This has led to severe environmental degradation.

In the same year, the findings of the Department of Pollution Control showed that nitrogen levels at the U-Tapao river mouth were three times higher than that in other areas; the amount of phosphorus in both the U-Tapao and Pawong river mouths was higher than that in other areas as well (NICA 2005). The high levels of nitrogen and phosphorus are primarily the result of wastewater from human activities being emptied into the lake. Chlorophyll A has grown in the lake. This indicates serious eutrophication, which endangers aquatic survival and gives rise to sudden fish die-off.

## Impact of Water Quality on Fishery Productivity

A study has identified a link between fishery production and water quality in Songkhla Lake (Pornpinatepong et al. 2010). Data on pollution levels and the lake's natural shrimp catch were analyzed (shrimp fishing is the most profitable economic activity that is carried out in Songkhla Lake). The link is shown in Figure 1.

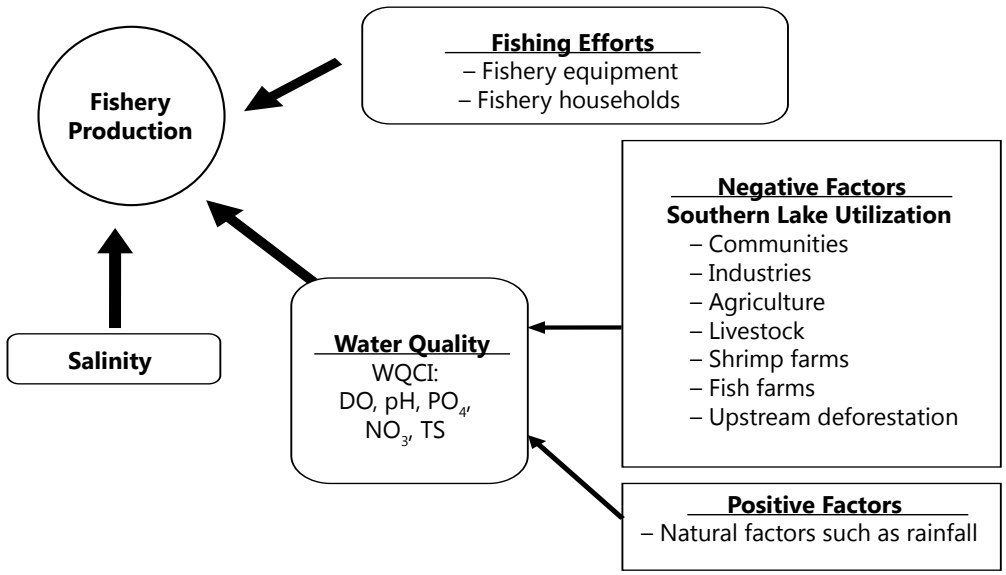


**Figure 1. Simple model showing the factors impacting fishery productivity in Southern Lake**

*Source:* Pornpinatepong et al. (2010)

The statistical analysis indicated that water-quality changes in the lake had a significant impact on shrimp production. In particular, it showed that a 1-unit increase in the water quality composite index (WQCI)[2] at U-Tapao would lead to a shrimp productivity increase of 3.4%; a 1-unit increase in the WQCI at Pak-ro would lead to a shrimp productivity increase of 10%. As the size of the shrimp harvest is linked to water quality, the value of the shrimp catch can be used as an indicator of changes in water quality.

## Water Quality Trends in Southern Lake

Based on 12 years of water quality data (1992–2004), the amount of nitrogen and phosphate discharged into Songkhla Lake has increased over time. The major sources of this pollution are the factories and pig farms that pollute the U-Tapao River and the Pawong Canal, both of which flow into the lake. Another important source of pollution is the Pak-ro Channel where there are a large number of shrimp ponds.

Although there has been a great deal of concern over the degradation in water quality, the problem has not yet been resolved. Appropriate policy options for more effective water quality management need to be considered.

## Management Options for Water Quality

### *Status quo*

Command-and-control (CAC) policy is the current water pollution management system in Thailand. Under this approach, factories, pig and shrimp farm entrepreneurs, and municipalities must comply with effluent standards and laws. The agencies that implement this legislation focus on crucial pollutants such as BOD, COD (chemical oxygen demand), and TKN (total kjendahl nitrogen). It is clear that this current policy is not effective. There are several reasons why the policy does not work:

1. It is inappropriate that water quality control standards include BOD concentration only, and not its volume.
2. The policy does not encourage industries to improve their production processes and wastewater treatment systems.

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*[2] The WQCI consists of five factors: DO, pH, $PO_4$, $NO_4$, and TSS, all of which were selected from the general water-quality parameters specified and used by the Department of Pollution Control. WQCI is calculated on the basis of the composite index method, in which each of the parameters is weighted according to its importance to water quality and aquatic animals. For more information, see the original research report by Pornpinatepong et al. (2010).*

3. The measures for controlling small-sized firms are unclear.
4. The monitoring procedures are inefficient and the punishments for those who exceed pollution standards are quite small and are not strictly enforced.

Morever, investment in wastewater treatment plants always involves a high cost, and therefore most dischargers avoid such investments where possible. This lack of investment leads to a large amount of pollution. For instance, up to 91% of pig farms and 100% of open-system shrimp farms in the U-Tapao catchment directly release untreated wastewater into the environment. It is therefore clear that there is a serious need for incentive mechanisms to be put in place in order to encourage dischargers to reduce their effluent.

### *A choice of market-based incentives*

The policy goal here is to achieve the desired total water pollution reduction targets effectively alongside sustainable water resources utilization. The study done by Pornpinatepong et al. (2010) shows the links between environmental problems, policy problems, impacts, and primary solutions for water quality control, based on the information shown in Figure 2.

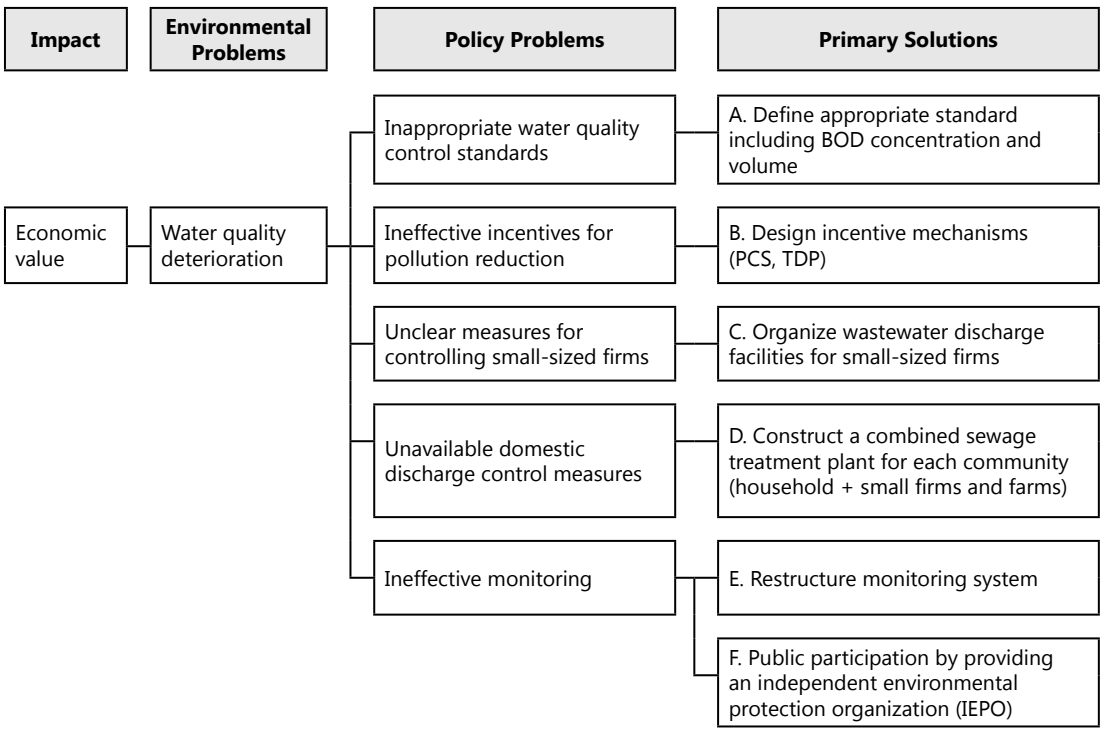


**Figure 2. The links between environmental problems, policy problems, impacts, and primary solutions related to Southern Lake**

*Source:* Pornpinatepong et al. (2010)

Market-based instruments are widely acknowledged to have many advantages over CAC regulations. Therefore, it is useful to compare the current CAC pollution management system with two potential market-based options.

***Policy Option 1:*** Command-and-control system (CAC)
Status quo plus changes in pollution evaluation methodology, which include both BOD concentration and volume, and strengthening the enforcement of the existing system.

***Policy Option 2: Emission charge system (ECS)***
An emission charge is a fee paid by a polluting factory. Under an ECS approach, the charge would be based on the amount of pollution a factory discharges. The funds collected would be used for industrial pollution management. They would be utilized as a circulating fund to provide assistance or support for the implementation of industrial pollution management measures. They would also be used for environmental quality monitoring. All factories and large and small firms that discharge wastewater into their surroundings would be obliged to pay this emission charge.

The factories will be divided into two types: "flat rate" and "variable rate." A flat-rate factory is classified by a BOD load of influent of less than 100 kg per day. Most factories that discharge relatively small amounts of wastewater are medium-sized or small-scale, and thus ongoing effluent monitoring is not required.

A variable-rate factory is classified by a BOD load of influent greater than 100 kg per day. Most large-scale factories generate considerable volumes of wastewater, hence effluent monitoring is required.

***Policy Option 3: Tradable discharge permit (TDP)***
ECS is applicable to all sizes of firms; however, it is difficult to define an optimal fee level. If the fee is too low, then it may not provide sufficient incentive for pollution control. Even if the fee is set at an optimal level, distortions may exist in the behavior of both the enterprises and the regulatory bureaus, which would lower the incentive for pollution control (Yun 1998). Interestingly, a TDP system provides more flexibility than ECS for firms to meet their discharge targets. A TDP system offers industrial firms the option to avoid meeting stringent effluent standards by purchasing effluent credits or permits from other firms that can reduce their effluent at a lower cost. This concept is applicable to the Southern Lake watershed because there are various industries with different abatement costs, and therefore the potential gains from trading effluent credits/permits are likely to be proportionately large.

A TDP system can therefore provide greater flexibility for firms to meet their discharge targets. Participants should include

1. large firms and domestic treatment facilities, which would be forced to enroll in the TDP system;
2. small firms, which would pay for their pollution via their district or municipality or via combined sewage treatment systems and enrollment in the TDP system; and
3. households, who would pay via the domestic treatment facilities system.

Also, the implementing agency can work with local industry associations, community organizations, and related government agencies to set up a monitoring and enforcement system. The TDP system is carefully designed and defines specifications, steps in the TDP, allocation of initial rights, participants, trading rules, etc.

However, on the negative side, a TDP system might be limited by high monitoring and transaction costs between a large number of small firms. (For more details, see Pornpinatepong et al. [2010]).

### *Which market-based system is best?*

Ten criteria are selected to compare the different policies. These are public acceptability, legal feasibility, implementation complexity, effectiveness, capital costs, operating costs, transaction costs, impacts, equity, and decentralization. It is found that both an ECS and a TDP system could provide companies with incentives to reduce pollution in a cost-effective way, as show in Table 1. However, each of these approaches has their own particular advantages and disadvantages.

It is clear that ECS suits smaller polluters because it involves lower capital costs. However, it is also clear that it would be difficult to define an optimal fee level for an ECS for the Songkhla Lake area. Such a fee would need to provide enough incentive to encourage pollution clean-up without being punitive. Getting this balance right would be a challenge.

**Table 1. Summary of the evaluation results of the three policy options**

| Criteria / Description | Measures | Research Result | | |
|---|---|---|---|---|
| | | CAC | ECS | TDP |
| **1. Public acceptability**<br>The acceptance level among key stakeholders, local administrative authorities, and government agencies | The degree of acceptance<br>(strongly disagree /disagree/agree/ strongly agree)<br>**Method:**<br>Focus group discussions | Agree | Agree | Disagree |
| **2. Legal feasibility**<br>The existing legislative framework to permit the policy options | Easy/somewhat easy/somewhat difficult/difficult<br>**Method:**<br>Historical data/expert judgment | Easy | Somewhat easy | Somewhat difficult |
| **3. Implementation complexity**<br>Extent of regulatory and legislative requirements | Degree of complexity<br>(very high/high/low/very low)<br>**Method:**<br>Historical data | Low | High | Very high |
| 4. **Effectiveness**<br>Extent to which the proposed policy options address the six factors in proper water quality control management | 1. Provide incentive mechanisms for pollution reduction<br>2. Interaction among and coordination of stakeholders for water quality improvement<br>3. The outcome effectiveness of the water quality control policy<br>4. Appropriate water quality control standards<br>5. The control of all sizes of firms<br>6. Availability of domestic discharge<br>**Method:**<br>Expert judgment/focus group discussions | Moderate | Moderate | High |
| **5. Capital costs**<br>Monetary costs of the initial investment in required equipment | 1. Number of activities needed<br>2. Comparing the cost of each activity<br>**Method:**<br>Expert judgment | Low | High | Higher |

*Table 1 continued*

| Criteria / Description | Measures | Research Result | | |
|---|---|---|---|---|
| | | CAC | ECS | TDP |
| **6. Operating costs**<br>Monetary costs of operating the option on a yearly basis | 1. Number of activities needed<br>2. Comparing the cost of each activity<br>**Method:**<br>Expert judgment | Low | Higher | High |
| **7. Transaction costs**<br>Monetary costs incurred in firm-to-firm interaction | 1. Number of activities needed<br>2. Comparing the cost of each activity<br>**Method:**<br>Expert judgment | Low | High | Higher |
| **8. Impacts**<br>**8.1 Positive impacts**<br>Impacts on aquatic environment, natural fishery, and aquaculture fishery<br>**8.2 Negative impacts**<br>The loss of competitiveness due to higher production costs | 1. The change in the economic value of the lake (fish productivity/recreational value)<br>2. The impact on output price<br>**Method:**<br>Expert judgment | Low<br><br>Low | High<br><br>Low | Higher<br><br>Low |
| **9. Equity**<br>Polluter pays principle | Number of dischargers included in the system (high/moderate/low/none)<br>**Method:**<br>Historical data | Low | High | High |
| **10. Decentralization**<br>Firms make decisions on pollution reduction | Number of firms that potentially reduce pollutants and set up plans for pollution reduction<br>**Method:**<br>Historical data/expert judgment | Low | Moderate | High |

The TDP concept would be an effective approach in the Songkhla Lake watershed. This is because there are varieties of industries in the region with different abatement costs. The potential gains from trading effluent credits or permits are therefore likely to be significant. However, there would also be some disadvantages with TDP. Firstly, implementing a TDP would require resolving various legislative issues. It would be complicated, and such a scheme would therefore require a greater initial investment and higher transaction costs. A TDP would also have a low public acceptability; people do not currently understand how such a system functions. Therefore, in order to implement a TDP in a community situation, outreach and education work would be required.

### *Final recommendations*

Due to the high outcome effectiveness of the TDP and its high capital costs, it would best be applied to large firms and farms. ECS would better suit small- and medium-scale firms and farms; thus, this should be applied to such businesses and households. Whichever combination of policy options is ultimately selected, further studies will be needed to iron out the details. Moreover, because each policy has inherent advantages and disadvantages, policy makers should assess each option against their own specific goals before they decide how to progress.

## Your Assignment

The Governor of Songkhla province has absorbed the management challenges on market-based policy from the research report, "Saving Songkhla Lake: Can Market Mechanisms Work?" However, he needs additional advice from Songkhla Lake stakeholders, particularly the government agencies connected to the lake's management, such as the Office of Environmental Policy and Planning, the Department of Fisheries, the Ministry of Natural Resources and Environment, as well as community leaders and NGOs. The Governor seeks advice on the following questions:

1. Using the information in this case study, identify the advantages and disadvantages of a "command-and-control system" and a "market-based system."
2. Please consider and select the set of criteria from the given information to assess, prioritize, and select management policy options. The weighting may be assigned based on group opinions.
3. In order to carry out the selected policy, additional information and future research may be needed. Identify these areas.

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Photo by Shaufique Fahmi Sidique

# The Impacts of Artificial Reefs on the Sustainability of Malaysian Fisheries

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Based on EEPSEA Research Report No. 2014-RR4: *Economic impacts of artificial reefs: The case of fisher households in Peninsular Malaysia* by Shaufique Sidique, Kusairi Mohd Noh, Gazi Md Islam, and Aswani Farhana Mohd Noh

*This case study describes the tension between policies with conflicting objectives in the Malaysian fishery sector. The industry is faced with dwindling catch due to declining marine resources. This affects the livelihoods of fisher households, which are classified as one of the poorest communities in Malaysia. The government has introduced resource rehabilitation measures such as artificial reef programs to improve the state of fisheries and ensure their long-term sustainability. There are also subsidy and incentive programs that are effective in reducing operation costs and in increasing fisher income in the short-term. However, although these incentives increase fishing capacity, they further deplete fishery resources. The is compounded by the limited budgetary allocation that forced policy makers to redistribute funding to these different policies. Different angles need to be considered, taking into account environmental, socioeconomic, and political motivations.*

*Case study users can be students of environmental-, natural resource-, or development economics-related subjects. They can also be decision makers with mandates related to fisheries, or nongovernmental organizations working on conservation issues. Each discussion group should employ the relevant economics principles when discussing their recommendations.*

## Introduction

Overfishing has resulted in the steady decline of fishery resources in Malaysia. Total fish landings in the Peninsular Malaysia declined from 8.23 million metric tons (t) in 1977 to 1.03 million t in 2011. Studies indicate that fishing vessels operating in all fishing zones have reached close to full technical efficiency and capacity utilization (Stobutzki et al. 2006). In other words, we are fishing faster than the fish population can grow. If this trend continues unabated, it will deplete our fish stocks. This problem is further compounded when excessive fishing capacity and efforts are also damaging marine habitats.

This worrying development in fishery exploitation severely affects the livelihoods of fisherfolk, especially artisanal fishers, whose fishing methods are far less efficient than those of large-scale fishers with trawlers. Depleting fish stocks means that fishers have to increase their fishing efforts to haul the same amount of catch as before. More fishing results in higher operating costs and subsequently translates to lower profits and income. A total of 134,110 fishers engaged in active fishing in 2011; 80,262 of them were artisanal fishers, whose incomes already sit within the poverty bracket.

The sustainability of Malaysian fishery is not a new issue. The authorities identified this issue and have adopted mitigation strategies such as deploying artificial reefs (AR) in marine waters. The earliest ARs were deployed in 1975. ARs are deployed within 5 nautical miles of the shoreline and are supposed to rehabilitate fishery resources and act as deterrents to encroaching trawlers. These 5 nautical miles are reserved exclusively for fishers operating artisanal gear such as hook-and-line and fishnets. Trawling in shallow water along the coastline poses serious threats to corals reefs, which is the spawning grounds and habitats for various marine species. It is hoped that the presence of ARs in coastal waters will contribute to the sustainability of marine resources while securing the livelihoods of Malaysian fishers, particularly artisanal fishers.

The Malaysian government has instituted various measures to boost the livelihoods of fishers. Subsidies are provided to individual-licensed fishers for their fishing boat and engine. Fishers are given a fuel subsidy and a monthly subsistence allowance as an incentive to fish actively. Output incentives are given based on the quantity of fish sold at the jetty. These subsidies aim to reduce the costs of fishing. However, the amount of money spent on these subsidies is astronomical. The government distributed billions of liters of subsidized diesel and petrol worth almost MYR 2 billion to fishers between 2009 and 2012. This staggering expenditure on fuel subsidy over a four-year period is tens of times more than the amount of money spent on AR programs in the past three decades.

## Concerned Government Departments

The Director General of the Department of Fisheries (DOF) is concerned about the state of Malaysian fishery. Reports citing dwindling catch are strong indications of depleted marine resources. Swift action needs to be taken to implement both short- and long-term measures to ensure the sustainability of marine resources and of the industry as a whole. Upgrading AR programs is one of the immediate measures that comes to the Director General's mind. However, recent developments in the Malaysian economy have not been encouraging. Economic growth is slowing and the debt-to-GDP ratio is increasing. One quick solution to reduce the ballooning public deficit is to cut the annual budget across most government agencies. DOF will not be spared from the cost-cutting measures. Spending more on AR programs will mean that less funds will be available for other areas that are equally important.

The Director General of the Fisheries Development Authority Malaysia (LKIM) is also worried. His agency is responsible for the development of the fishery industry, with an emphasis on increasing efficiency, landings, and improving the marketing supply chain. LKIM is also directly responsible for improving the welfare and livelihood of fishers. The agency has been deploying ARs as fish-aggregating devices (FAD) since the 1970s to help increase fish population and subsequently improve catch. It is also responsible for providing most of the fisheries subsidies. An annual budget cut would result in prioritizing expenditures, and this might affect the welfare of fishers.

At the Economic Planning Unit (EPU), an agency under the Prime Minister's department, its Director General is mulling over the reduction in budgets for different ministries and

departments. Fuel subsidies for the fishery sector represent a huge proportion of total government subsidies. However, reducing the fuel subsidy will increase the operating costs in the fishery industry. Apart from lowering a fisher's income, this cost increase will manifest itself as an increase in fish prices. He knows, in the current economic conditions, that policies that result in price inflation and the decrease in household income are unpopular. However, he also understands the trade-offs he will be making. A politically popular policy is often not the best solution to any given situation. Artificially lowering fishing costs by handing out fuel subsidies results in higher-than-optimal fishing efforts that will negatively affect the country's fish stocks. Although increasing budgets for AR programs will help improve marine resources, the positive impact of this policy will only be felt in the future.

## Artificial Reefs in Malaysia

ARs were initially deployed in Malaysian coastal waters in 1975 by DOF and LKIM. Early ARs had been made of tires, derelict boats, and concrete cuboids until they were replaced by more durable materials and structures in 1985. The materials used for ARs include reef balls, abandoned oil rigs, ceramic structures, and concrete-based ARs of various shapes and designs. The costs of ARs vary by size and material. On the average, a relatively small AR (made of concrete reef balls or cuboids) would cost about MYR 1,000; a large AR complex (comprising 20 units of concrete blocks) would be MYR 300,000. The government has spent more than MYR 100 million on AR programs in Malaysia over the past 30 years.

DOF-ARs are deployed more than 3 nautical miles (in a sandy habitat) away from the shore at an average depth of 15–20 meters (m). These ARs are especially designed to protect the habitat from trawler nets. ARs from the Fisheries Development Authority Malaysia, also known as *unjam-unjam*, are relatively smaller than DOF-ARs; they are usually placed on the seabed within 3 nautical miles (in a muddy habitat) of the shore. LKIM *unjam-unjam* are installed when they are requested by artisanal fishers. LKIM-managed ARs function as FADs that are mainly focused on increasing resource access, catch, and the income of artisanal fishers.

## Documented Studies on Artificial Reefs

The mixed reviews of the literature on the economic performance of ARs make it difficult to draw clear conclusions. Having said this, it is important to recognize that several studies from across the world have given a positive impression of the economic performance of ARs (Polovina and Sakai 1989; Johnson et al. 1994; Venkatasami and Mamode 1995; Yodee 1994). In Japan, data on catch before and after installing ARs found that there had been an increase in octopus production (Polovina and Sakai 1989), with similar results for other species being found in the case of Thailand (Yodee 1994). This latter empirical study used a bio-economic model to assess the economic performance of ARs; the study also estimated that the income of the local community had increased due to the installation of ARs despite the price of the catch remaining almost constant during the studied period. A study on ARs in Southern California discovered that ARs had provided nine times greater catch than in areas without

ARs in the studied region (Johnson et al. 1994). Similarly, Venkatasami and Mamode (1995) looked at the use of FADs in Mauritius and found that they had increased fish productivity.

There has been a lot of interest in developing ARs and FADs in Southeast Asia, mainly because the region has suffered from intense overfishing and severe degradation of marine and coastal habitats (Delmendo 1991; Chou 1997). Regrettably, while the installation of ARs has been widespread, less consideration has been given to collecting the necessary baseline data that could help assess the economic performance of ARs (Delmendo 1991). Fortunately, in the case of FADs, which are not fixed structures like ARs, an assessment of their performance with regard to fish productivity is easier to perform. Results from the Philippines have shown that they have been successful for tuna production (Delmendo 1991).

The proliferation of AR deployments on the Malaysian coastline has been substantial, but there have been very few studies that have assessed their effectiveness at improving artisanal fishers' livelihoods. Viswanathan, Kusairi, and Tai (1996) studied the issue and found interesting results. Using regression analysis, they took data from 46 AR sites around Peninsular Malaysia and found that the age, size, and location of the ARs had a significant effect on the fishers' income. A drawback of their study, which they pointed out, is that more time is needed to assess the long-term economic impact of ARs on artisanal fishers' income. A related study, which did not look at the effect of ARs but instead looked at the impact of FADs on freshwater fish production in Terengganu, was conducted by Ibrahim, Matusin, and Hajisamae (2000). This study compared its results with baseline data and found that FADs were successful in attracting fish. More recently, a project near Pulai Langkawi in Kedah monitored the installation of ARs in 2007. Preliminary results suggested that the ARs had slightly improved the income of the local fishing community; however, the study could not draw any conclusions regarding the long-term economic impacts as the ARs had only recently been installed.

Squires et al. (2003) focused on the fishing practices of Malaysian artisanal fishers. The study highlighted that the artisanal fishers' fishery resources were overexploited; however, the artisanal fishers themselves were technically efficient. This suggests that increasing current marine resources, rather than training artisanal fishers to be more efficient, is the best strategy. They also stressed the importance of fisheries as a key livelihood for local communities, some of which derived almost all of their income from marine fishing. Providing artisanal fishers with devices that help improve their fish productivity therefore seems to be crucial. For this reason, an evaluation that quantitatively measures the contribution of ARs to increasing artisanal fishers' income is an important area of research. The most recent study of this type was conducted by Economy and Environment Program for Southeast Asia in 2012, which looked at the impact of ARs on the income of fisher households in Terengganu. The study found that fishers who operate in AR areas have a more valuable monthly catch than those who fish in non-AR areas. However, the study also found that there are some management and equity issues relating to ARs that need to be resolved. The study therefore recommended establishing policy measures that would map and manage ARs properly. It also recommended putting in place various instituting policies to help poorer artisanal fishers hold their own against fishers using more advanced boats and fishing technology.

## Subsidies and Incentives in Malaysian Fisheries

Subsidies were first introduced in the fishery industry in the early 1970s with the primary aim of eradicating poverty. The subsidy program provided direct assistance to individual small-scale fishers to help free nonowner operators from their bonds to boat and gear owners. Currently, a wide range of subsidies and incentives are available to Malaysian fishers. Some of these subsidies and incentives are given based on four different fishing zones: Zones A, B, C, and C2. Zone A is assigned to coastal fishers operating within 5 nautical miles and is reserved for artisanal fishers and small vessels operating traditional gear. Zone B is assigned to vessels below 40 gross registered tons (grt) operating 5–12 nautical miles from the shoreline and is reserved for trawlers and purse seiners. Zone C is for vessels below 70 grt operating within 12–30 nautical miles. Zone C2 is for offshore vessels greater than 70 grt operating more than 30 nautical miles from the shore.

Table 1 shows the different types of subsidies and incentive programs (by fishing zone) available in 2013. Subsidies and incentive programs include livelihood and catch incentives, and a fuel subsidy. Each boat is entitled to receive a livelihood subsidy for two fishers (the captain and one crew member). A catch incentive scheme entitles fishers to claim MYR 0.10 per kilogram of catch for Zones A, B, and C; and MYR 0.20 per kilogram of catch for Zone C2. The maximum catch that fishers can claim in the different zones varies between MYR 150–350 for Zone A; MYR 750 for Zone B; MYR 1,500 for Zone C; and MYR 5,000 for Zone C2. A fuel subsidy is provided to boats with either petrol or diesel engines.

**Table 1. Fisheries subsidies and incentive programs by fishing zone, 2013**

| Subsidy Component | Unit | Zone A | Zone B | Zone C | Zone C2 |
|---|---|---|---|---|---|
| Livelihood incentive | (MYR/mo) | 200 | 200 | 200 | 200 |
| Catch incentive | (cent/kg) | 0.10 | 0.10 | 0.10 | 0.20 |
| Maximum catch incentive | (MYR/mo/pax) | 15–350 | 750 | 1,500 | 5,000 |
| Diesel subsidy | (MYR/l) | 0.55 | 0.55 | 0.55 | 0.00 |
| Petrol subsidy | (MYR/l) | 0.65 | 0.65 | 0.00 | 0.00 |
| Diesel subsidy price | (MYR/l) | 1.45 | 1.45 | 1.45 | *2.00 |
| Petrol subsidy price | (MYR/l) | 1.45 | 1.45 | 0.00 | 0.00 |
| Diesel limit | (l/mo/boat) | 15,000 | 20,000 | 28,000 | 32,000 |
| Petrol limit | (l/mo/boat) | 1,560 | 1,560 | 0 | 0 |
| Diesel limit | (MYR/mo/boat) | 8,250 | 11,000 | 15,400 | 0 |
| Petrol limit | (MYR/mo/boat) | 1,014 | 1,014 | 0 | 0 |

*Source:* LKIM (2013)
*Notes:* (1) Zone A: in-shore; Zone B: offshore, trawlers, and purse seines less than 40 grt; Zone C: trawlers, purse seines more than 40 grt; Zone C2: trawlers, purse seines more than 70 grt (2) *Zone C2 boats are not entitled to receive the super subsidy, but they receive the normal subsidy as they can buy diesel at MYR 2.00 from pump stations; this fuel is already subsidized by the Malaysian government. (3) mo = month; kg = kilogram; l = liter

Additionally, fishers are also entitled to receive money from a loan scheme called the Azam Tani program. This program comprises six loan schemes available for the following: subsidies for boats, engines, fishing gear (nets), natural disasters (flooding), tsunamis, and the upgrading of vessels. LKIM and local fisheries associations are responsible for managing subsidies and incentives at a community level. DOF is in charge of the registration of fishing boats, which qualifies registered fishers for different schemes. The total amount of fisheries subsidies and incentives available are summarized in Table 2.

**Table 2. Total subsidies (in MYR) available, Peninsular Malaysia, 2009–2012**

| Components of Subsidies | Year | | | |
|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 |
| Livelihood incentive | 105,382,400 | 173,761,400 | 82,924,000 | 172,831,200 |
| Catch incentive | 33,437,417 | 34,258,752 | 53,135,869 | 63,739,882 |
| Diesel subsidy | 387,518,780 | 429,390,275 | 400,952,761 | 424,433,933 |
| Petrol subsidy | 45,168,116 | 44,845,339 | 44,933,360 | 49,522,623 |
| Others support programs | 11,715,614 | 12,405,750 | 69,129,727 | 4,199,950 |
| Total subsidy | 583,222,327 | 694,661,515 | 651,075,717 | 714,727,588 |

*Source:* LKIM (2013)
*Note:* Other support programs include Dana, LKIM scheme, loans, etc.

## Your Assignment

The EPU Director General remembers you, his old college friend, as a person who is interested in environmental economics. He knows that you are now a college professor and still pursuing your old interest. You are called in for a meeting and appointed as a consultant to EPU to study how to rationalize the recent budget cuts. Specifically, the Director General seeks your advice on how to prioritize expenditure on the fishing industry to ensure its long-term sustainability and the current welfare of the fisher community. How do you balance and manage the tensions between conservation efforts, livelihoods, and political incentives?

1. How do you rank the following fisheries policies?
   - AR programs
   - Fuel subsidy
   - Boat and engine subsidy
   - Catch incentive
   - Subsistence allowance
2. What criteria should you use to rank the above-mentioned policies?

   You are scheduled to meet the EPU Director General in two days time. Your task is to prepare a document that outlines the key messages on this issue so that he is well-briefed before he meets the Minister of Agriculture and Agro-Based Industry next week.

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Mangroves plantation in Aklan, Philippines. Photo by Ree Dexter
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# Is There a Way to Restore the Mangroves after Typhoon Yolanda?

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Based on EEPSEA Research Report No. 2011-RR9: *Reversion of disused fishpond lease agreement areas to mangrove forests in Region VI, Philippines* by Alice Joan G. Ferrer, Jinky C. Hopanda, Michael Q. Orquejo, Alan Dino E. Moscoso, and Resurreccion B. Sadaba

*This case study deals with decision making involving mangrove protection and rehabilitation in the context of limited time and financial resources. It is an exercise in the trade-offs between three options, each of which has its own strengths and weaknesses.*

*Knowledge of the pros and cons of trade-offs, cost-benefit analysis, policy analysis, and the biology of mangroves would be useful for analyzing this case study. A set of evaluation criteria that considers economic, social, political, and biological requirements should be formulated. This case study illustrates that economics is a discipline that offers tools for analysis and makes significant contributions to good decision making.*

*Intended users of the case study include natural resource managers at the national and local levels, nongovernmental organizations working on environmental protection and management, and graduate students on natural resource management courses. Although the case study takes place in the Philippines, it can be applied to other countries facing similar dilemmas over how to return mangroves to their original state.*

## Introduction

Considered the strongest tropical cyclone to make landfall in recorded history, Typhoon Yolanda (International name: Haiyan) uprooted trees, destroyed buildings, and brought storm surges of up to 6 meters (m). The typhoon destroyed coastal communities in 8 of the 17 regions of the Philippines, and affected 16 million individuals or 3.4 million families. The damage caused by Yolanda is estimated at PHP 38.9 billion (USD 905 million), broken down into damage to infrastructure at PHP 19.6 billion (USD 444 million) and damage to agriculture at PHP 20.2 billion (USD 461 million) (NDRRMC 2014).

In the midst of the chaos that came in the aftermath of Typhoon Yolanda, news stories by the *Public Radio International* (29 November, 2013) and the *Philippine Daily Inquirer* (29 November, 2013) featured how lives were saved owing to the mangroves located in small coastal communities in General MacArthur, Eastern Samar and Molocaboc Island, Sagay City, Negros Occidental. People in these communities attributed their zero casualties to mangroves. These communities remind us of the value of mangroves, while the rest of the Visayas region struggles to regain much of what they have lost to Typhoon Yolanda.

## Mangroves are Important

Mangroves act as natural barriers in coastal areas, protecting communities from storm surges, waves, tidal currents, and typhoons. Scientific evidence shows that a barrier of mangroves over 100 m wide can reduce wave height by between 13% and 66% (McIvor et al. 2012a). Moreover, a per kilometer width of mangroves can weaken storm surge by 5–50 centimeters and surface wind waves by more than 75% (McIvor et al. 2012b).

Aside from these typhoon-arresting benefits, mangroves provide nursery grounds for fish, prawns, and crabs; and support fishery production in coastal waters. They are also a good source of wood, timber, and nipa shingles for housing material, firewood and charcoal, and of poles for fish traps. The total value of mangroves is estimated at USD 14,000–16,000 per hectare, of which about 80% is coastal protection value (Barbier et al. 2011).

## Mangroves are Disappearing

Unfortunately, significant areas of mangrove forest have been lost or degraded in the Philippines (Genio et al. 2007). The country no longer has the optimal mangrove-pond ratio of 4:1 (4 hectares [ha] of mangrove to 1 ha of fishpond) that would ensure a healthy ecosystem (Primavera 2005). In 1994, the total mangrove area was placed at 120,000 ha while fishponds covered 232,000 ha or a ratio of 0.5:1.

These massive losses of mangroves happened in the 1950s and 1980s when the government encouraged aquaculture in order to increase food production in the country. Using funding from external sources (the World Bank and the Asia Development Bank), the government extended loans that resulted in intensive aquaculture and the conversion of many mangrove areas into fishponds (Primavera 1995; Escober and Jacinto 2006; Hishamunda et al. 2009). Around half of the 279,000 ha of Philippine mangroves that disappeared between 1951 and 1988 were converted into milkfish or shrimp ponds under Fishpond Lease Agreements (FLA) (Primavera 2005).

## How Can We Bring the Mangroves Back?

Two ways have been identified to restore the mangrove-to-pond ratio: (1) protecting the remaining mangrove cover and (2) rehabilitating degraded sites. A number of reforestation projects in the country have been supported by the Department of Environment and Natural Resources (DENR) where funds from national or foreign sources have been used (Primavera and Esteban 2008; Samson and Rollon 2008). Favored sites are seafront or lower intertidal to subtidal zones, which are not the natural habitat of mangroves. Most reforestations have converted these areas into monospecific *Rhizophora* mangrove forests. The same route has been taken in the National Greening Program of the Arroyo administration, launched in 2011. Planting mangroves has provided employment in coastal areas.

Mangrove experts recommend returning the mangroves to their original habitat, which is in the middle to upper intertidal zone (Primavera and Esteban 2008; Samson and Rollon 2008). However, most of these areas (in either private or public ownership) have long since been converted into brackish-water fishponds.

A brackish-water fishpond on public land should have FLA, which is "an agreement entered into by and between the Secretary of Agriculture (DA) and qualified fishpond applicant for the use of public land for fishpond development purposes for a period of twenty-five (25) years" (Section 1, FAO 197-1). These public lands (i.e., mangrove forestlands and other swamps) were released to the Philippine Department of Agriculture (DA) by the DENR for fishpond purposes.[3] The Philippine Bureau of Fisheries and Aquatic Resources (BFAR) under DA is the agency responsible for the issuance of FLAs.

A total of 4,518 FLAs covering an area of 59,556.09 ha have been issued since 1973 (Table 1).[4] As of 2010, 202 FLAs have been cancelled, covering an area of 6,389.59 ha (Table 2). The FLAs were cancelled due to violations of the terms and conditions of the agreement, e.g., not developing the area for fishpond purposes (abandoned) or not paying the rental for years. Thirty-six of these areas, covering a total of 1,343.32 ha, have been reverted to DENR control. However, none of these areas have been restored into mangrove forest. Many people believe that if there was to be an inventory of FLA areas, more of these areas could be returned to DENR control and would be suitable for reversion to mangrove forest.

**Table 1. FLAs issued in the Philippines, 1973–2010, by region**

| Region | No. of FLAs | % | Total Area (ha) | % |
|---|---|---|---|---|
| Philippines | 4,518 | 100.00 | 59,556.09 | 100.00 |
| Region I | 207 | 4.58 | 1,272 | 2.14 |
| II | 8 | 0.18 | 78.71 | 0.13 |
| III | 76 | 1.68 | 519.66 | 0.87 |
| IV | 763 | 16.89 | 11,528.64 | 19.36 |
| V | 462 | 10.22 | 7,278.31 | 12.22 |
| VI | 1,487 | 32.91 | 14,253.19 | 23.93 |
| VII | 452 | 10.00 | 4,530.54 | 7.61 |
| VIII | 211 | 4.76 | 5,207.19 | 8.74 |
| IX | 422 | 9.34 | 8,253.69 | 13.86 |
| X | 69 | 1.53 | 1,481.64 | 2.49 |
| XI | 137 | 3.03 | 1,435.70 | 2.41 |
| XII | 81 | 1.79 | 1,200.99 | 2.02 |
| XIII | 143 | 3.16 | 2,515.84 | 4.22 |

*Source:* BFAR (2010)

[3] *DENR has ceased releasing public land for fishpond purposes per Memorandum Order 98-17 signed on 3 November, 1998.*

[4] *The origin of Fishpond Lease Agreements (FLA) can be traced to FAO 14 of 1937. However, many of the areas covered by FLAs that were declared "alienable" and "disposable" were sold and eventually titled. With the passage of Presidential Decree 704 in 1975, this practice was stopped. Section 23 of the Decree states that "no public lands suitable for fishpond can be disposed by sale; only those fishpond sales patent already processed and approved on or before November 9, 1972, shall be given due course."*

**Table 2. Cancelled FLAs, areas covered by these FLAs, by region**

| Region | No. of Cancelled FLAs | Area Covered (ha) | No. of Areas Covered by FLA Reverted to DENR | Area Reverted to DENR (ha) |
|---|---|---|---|---|
| Philippines | 202 | 6,389.57 | 36 | 1,343.32 |
| Region I | 2 | 8.72 | – | – |
| II | 4 | 245.73 | 2 | 11.80 |
| III | 2 | 16.28 | – | – |
| IV | 44 | 1,852.10 | 3 | 364.57 |
| V | 27 | 508.46 | 1 | 12.49 |
| VI | 63 | 1,330.92 | 21 | 477.75 |
| VII | 17 | 519.51 | 3 | 36.79 |
| VIII | 13 | 656.27 | 1 | 33.53 |
| IX | 17 | 972.69 | 4 | 371.38 |
| X | 3 | 34.57 | – | – |
| XI | 2 | 35.74 | – | – |
| XII | – | – | – | – |
| XIII | 8 | 208.57 | 1 | 35.01 |

*Source:* BFAR (2010)

However, many FLA lessees are politicians (past and present), businessmen, or wealthy individuals. These people are considered "untouchable"; they are "risky" to deal with, even if they clearly violate the terms of the FLA. Often, their FLA areas are fenced and local people report that these areas are guarded by armed caretakers. FLA cancellation can result in long legal battles between the lessees and BFAR. The agency has limited human resources to dedicate to work related to FLAs. At a national level, BFAR has only three staff members assigned to FLA-related work, which is just one of the many programs and concerns BFAR has to attend to.

Cancelling an FLA does not always result in the administrative reversion of the FLA area to DENR. After cancellation, the FLA area may remain open for FLA applications or may continue under BFAR's jurisdiction, even if the area is designated to return to DENR control. Note that not all FLA areas are suitable for biophysical reversion to mangrove forest.

## Your Assignment

In the aftermath of Typhoon Yolanda, the Philippine President instructed DENR to take urgent action regarding planting and rehabilitating mangroves in order to prevent a repeat of the deadly storm surges that had claimed hundreds of lives on 8 November, 2013. DENR is given a budget of PHP 1 billion (USD 22.7 million) to spend over the period of one year.

Mangroves take 15 years to mature. Typhoons, on the other hand, have become more frequent and stronger. You are the DENR Secretary, with many other environment programs to run. The following questions need to be addressed:

1. What are you going to do to bring the mangroves back?
2. What options are available?
3. How will you allocate the PHP 1 billion year-long mangrove rehabilitation budget?

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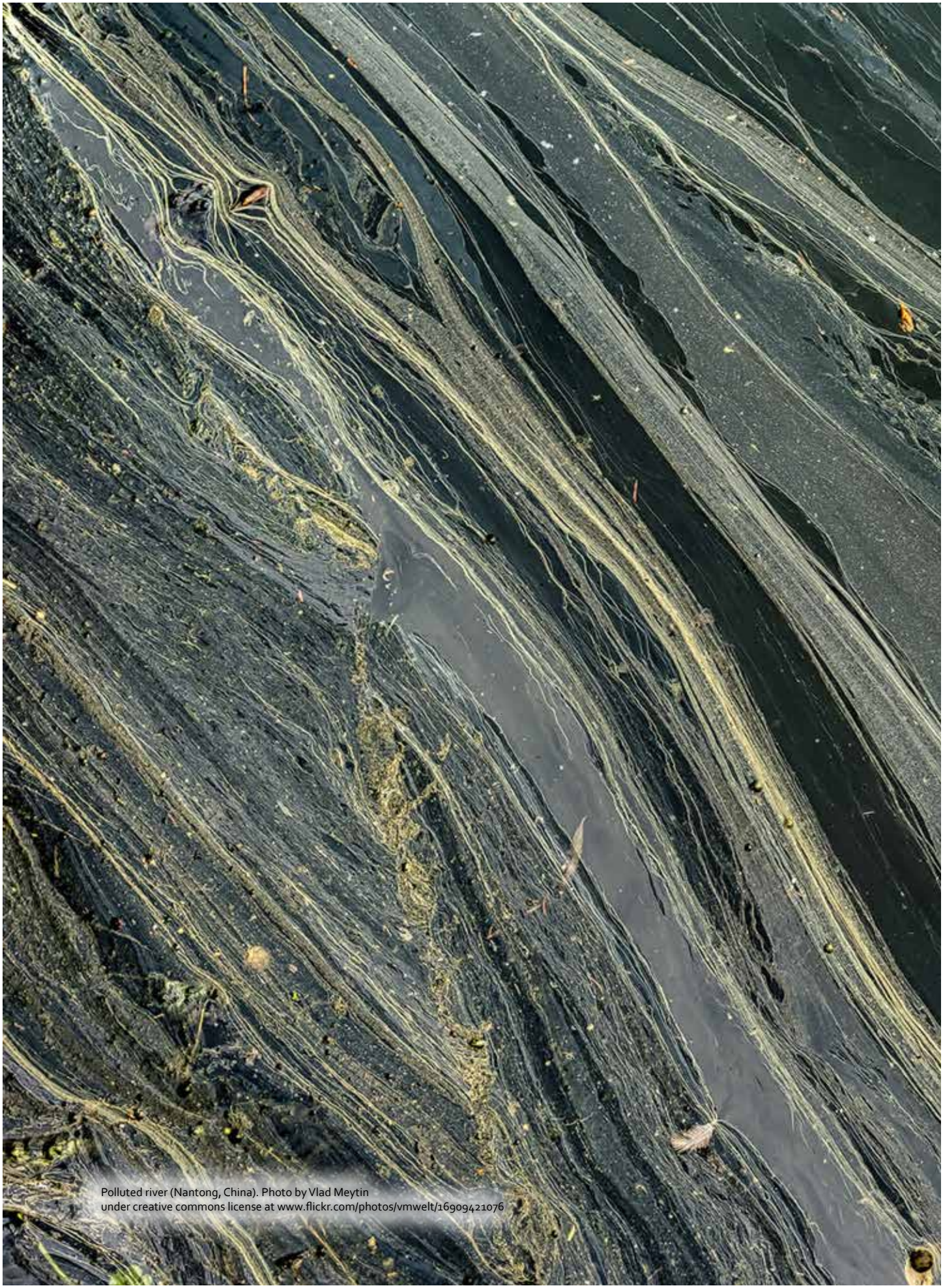

Polluted river (Nantong, China). Photo by Vlad Meytin
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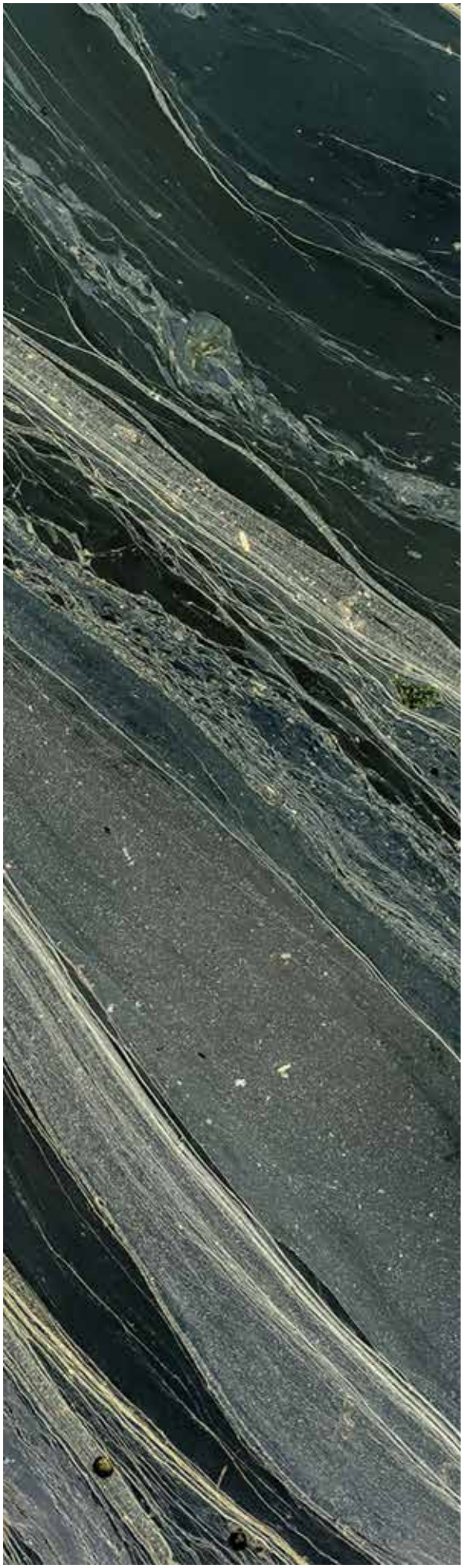

# 3

# Dealing with Water Pollution Issues

Hog raiser in North Cebu, Philippines. Photo by Unitarian Universalist Service Committee under creative commons license at www.flickr.com/photos/uusc4all/15457048980

# Cleaning Up the Sty: Regulating Nonpoint Source Pollution

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Based on EEPSEA Research Report No. 2001-RR6: *Backyard and commercial piggeries in the Philippines: Environmental consequences and pollution control options* by Maria Angeles O. Catelo, Moises A. Dorado, and Elpidio Agbisit, Jr.

*This case study highlights the difficulties of regulating nonpoint sources of pollution given the problems local government units encounter when trying to implement and monitor compliance with environmental regulations. The reasons for these difficulties range from the cost of administering regulation to the cost of obtaining information on who is causing the pollution. The study also highlights the problem of local government officials who are responsible for implementing environmental regulation but who also simply ignore this regulation if it damages their own business interests—even if this results in environmental degradation and negative health impacts on community members; this practice is now becoming a source of conflict among various stakeholders.*

*Although the context of this case study is nonpoint source pollution, particularly as a result of backyard waste or from small-scale hog raisers, similar situations exist in other Southeast Asian countries where pig production and consumption is dominant, and where local government politics play an important role in environmental management.*

*Case study users can be decision makers with mandates related to water, soil, and air pollution; government officials; nongovernmental organizations working with local backyard animal production; and local governments trying to regulate nonpoint source pollution. In using the case, each discussion group should include an environmental economist or an economist with a background in financial and economic analysis. Individuals with backgrounds in institutional and regulation economics may also be useful.*

*This case study can be used to demonstrate that economic analysis and incentives can contribute to finding options that regulate nonpoint sources of pollution, and therefore improve environmental quality. However, the issues at hand may be more intricate and complex in the real world and may require a more comprehensive understanding of social, cultural, political, and legal dynamics and powerplay.*

## Introduction

The Tres Marias pig farm is a promising business that holds an average of 20 pigs and is considered "backyard" in scale. The Oink-Oink pig farm is also a thriving enterprise but has an average herd size of 1,000 pigs and is classified as a commercial farm. Both farms are located in a peri-urban area called Los Bandidos.

The Tres Marias and Oink-Oink pig farms are just two of the many farms that produced 13 million pigs in the country of Piggylandia in 2013. The entire livestock industry was valued at about USD 5 billion in 2013, and the pig sector accounts for about 80% of this industry. In fact, the hog industry is the second fast-growing agriculture subsector next to rice. As such, the hog industry is seen as a route out of poverty, particularly as 65% of pig stock is raised in backyard farms.

## Tensions

There is a price to be paid for this thriving industry. Neighbors who live within a radius of 1 kilometer (km) of the Tres Marias and Oink-Oink farms complain of a foul odor and of noise, especially when it is time to clean the pens and feed the animals. Neighbors also have to endure feeling nauseous, headaches, foul odor sticking to their clothes, respiratory and gastrointestinal problems, skin allergies, and conjunctivitis (Catelo, Dorado, and Agbisit 2001). About 10%–20% of the 100 families that live close to these pig farms spend an average of USD 220 every year for treating these illnesses.[1] This sum is equivalent to the monthly minimum wage in Los Bandidos.

The illnesses experienced by local residents can be illustrated by the case of Mr. Angal, who has suffered from pneumonia and whose house is located next to a huge commercial pig farm. When Mr. Angal built his house 10 years ago, little did he know that a commercial piggery would later be established a few meters away—despite the fact that zoning regulations prohibit pig farms to be established within 1 km of residential areas. Five years ago, Mr. Angal made representations about his situation to the mayor and the councilors who constitute the local legislating body (the *Sangguniang Bayan*). His complaints fell on deaf ears—perhaps because the mayor and a number of the councilors are pig farmers.

Mr. Angal remains vigilant and he is involved in a very active citizens group, the *Bantay Tao* Guild (BTG), which has a media arm. Mr. Angal plans to continue to air his views via the BTG and now the mayor is torn between allowing the pig farm owners to carry on business-as-usual or cleaning up the sty—which will cost him and all the other pig farmers

[1] *For more information about the health and environmental effects of untreated pig waste, see Catelo, Dorado, and Agbisit (2001).*

at least USD 370 each for a small biogas digester, with annual operating expenses of USD 200–300. Moreover, the mayor is uncertain whether there are sufficient public funds such that the city can subsidize investment in an organic fertilizer-pelleting plant in order to address the pig waste problem in the city, especially if individual pig farmers decide not to pay their way.

Adding to the mayor's stress is the news that the Secretary of the Environment and Natural Resources, Mr. Enre, has called up to announce that he will be coming to the mayor's office together with the Chief of the Baywatch Commission[2] to check on the status of the pig farmers' compliance with environmental regulations in Los Bandidos. This is in view of Piggylandia's bid to be declared free of foot-and-mouth disease (FMD) and tourist-friendly (Los Bandidos used to be known for its pristine waterfalls, rivers, and streams but the last time that the Secretary came to this municipality was five years ago). Mr. Enre's visit has also come about because BTG wrote to him about the plight of Mr. Angal and his fellow community members.

## The Meeting

The mayor decides to call a meeting of his cabinet and other stakeholders to help him decide what to do. Invited to the meeting are the following local officials of Los Bandidos: the finance officer, Ms. Pera; the city environment and natural resources officer, Mr. Centro; the chairman of the city councilors, Mr. Konsehal; and the president of the association of pig farmers and owner of Oink-Oink farm, Ms. Babs. The mayor also invites Mr. Angal, the community representative.

The mayor informs the meeting that Secretary Enre and the Chief of the Baywatch Commission are coming to visit. The mayor also tells at the meeting the Secretary and Chief's reasons for visiting. Then, he asks Mr. Angal to present his case again.

Mr. Angal has this to say:

> *"Besides the wide range of diseases and discomforts that are experienced by people like me who live near pig farms and who are constantly exposed to the malodors and ill-disposed pig waste, our creeks, rivers, and other water bodies have become polluted due to the indiscriminate dumping of wastewater from the piggeries. I have interviewed our senior citizens about this situation, and they claim that they can recall seeing people swim and wash their clothes in the nearby streams and rivers just five years ago. People can no longer do these things because of the water pollution caused by the proliferation of pig farms in the area.*

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[2] *A special regulatory agency of the Department of the Environment and Natural Resources created in 1966 as a quasi-government agency that leads, promotes, and accelerates sustainable development in the L-Bay*

*However, I know that the claims of our older citizens may not count in any court case; the only way to win a case is to produce concrete evidence beyond reasonable doubt that the water pollution was created by pig farm owners.*

*Thus, I have engaged the services of a research team from the Economy and Environment Program for Southeast Asia (EEPSEA) who conducted water sample tests[3] from different discharge and sampling points, upstream, and downstream in Los Bandidos. The test results show that, except for the Botocan River (upstream with biological oxygen demand [BOD] of 37 milligrams per liter [mg/l]), the other surface water and raw wastewater from pig farms had BOD[4] levels ranging from 110 to 325 mg/l. The national BOD standard for Class C water[5] is 50 mg/l for a new piggery and 80 mg/l for an old/existing piggery. This is evidence to support our claim that the major pollutants in the river and stream network come from wastewater from piggeries."*

After hearing Mr. Angal's case, Mr. Centro says that to bring charges against and impose fines on large commercial pig farms such as Oink-Oink is a straightforward matter because these farms have wastewater pipes that are easy to spot—so if these farms do not install waste treatment or do not do any waste minimization activities, this lack of compliance can be seen. In contrast, it is a huge task to regulate the hundreds of backyard pig farms that are dispersed across Los Bandidos and the thousands of small-scale farms that raise pigs all over Piggylandia.

## The Options

The mayor asks Mr. Centro to dig into the files of local ordinances and national laws to protect the environment. A few minutes later, Mr. Centro finds Board Resolution (BR) No. 169,[6] which was enacted by the Baywatch Commission. The resolution revealed, through the same EEPSEA research that Mr. Angal cited, that all the wastewater from all the piggeries drain into the L-Bay, the largest freshwater lake in the whole of Piggylandia. L-Bay is under the jurisdiction of the Baywatch Commission itself.

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[3] *For more information about the health and environmental effects of untreated pig waste, see Catelo, Dorado, and Agbisit (2001).*

[4] *Biological oxygen demand (BOD) is a water pollution parameter.*

[5] *Class waters are fresh surface waters whose beneficial uses include (1) fishery water for propagation and growth of fish and other aquatic resources, (2) recreational water Class II for boating and other activities not entailing personal contact with the water, and (3) industrial water supply Class I (for manufacturing processes after treatment) (Catelo, Dorado, and Agbisit 2001).*

[6] *Details of this resolution can be found in Catelo et al. (2007).*

The mayor also discovers that BR No. 169 already contains the benefits and costs of various technical, policy, and institutional options to address the harmful health and environmental effects of untreated pig waste. These were also derived from the recommendations of the EEPSEA research team, and have already been estimated and presented in a meeting of several stakeholders: the Tres Marias and Oink-Oink farm owners and other pig farmers, Mr. Angal and fellow community households, local *barangay* (village) captains, and the mayor and his councilors and representatives of the Baywatch Commission. Unfortunately, the mayor and his local government did not implement BR No. 169—for reasons that will be unearthed in the upcoming meeting with the Secretary.

The recommendations for which estimates of benefits and costs are available are as follows:[7]

1. Installation of waste minimization options such as mechanical drinkers and water drums (USD 10–50) in backyard pig farms with penalties or the cancellation of business permits for those who do not comply
2. Installation of treatment plants or biogas digesters to convert methane to energy for cooking (USD 10 monthly savings in terms of liquefied petroleum gas or LPG saved and electricity needs of the farm); economically viable for commercial but not for backyard farms unless there is a twin-sharing or even a communal system
3. Establishment of a lagoon system that will yield liquid fertilizer for croplands; this is not economically viable for backyard pig farms
4. Operation of an organic fertilizer pelleting plant (investment cost: USD 2,500; operating and maintenance cost: USD 500 annually) that can take care of the pig waste; but collection may be extremely difficult and investment may be huge for a single farmer unless the entire municipality of Los Bandidos make the investment or the private sector invests. This recommendation is economically viable if it is made into a communal activity.

Other regulatory instruments include the following, but more information is needed for better decision making:

1. Implementation and charging of environmental user fees already legally in place
2. Zoning ordinance whereby pig farmers are relocated away from residential areas
3. Subsidy to commercial pig farmers to install waste treatment facilities or systems
4. Local abattoirs mandated to accept only pigs raised in farms that use clean or green technology

[7] *Details of cost and treatment options are found in Catelo, Dorado, and Agbisit (2001).*

## Your Assignment

You are the right-hand person of the Secretary of the Department of the Environment and Natural Resources. You need to know what went wrong after the previous stakeholder meetings took place and after BR No. 169 was created. You need to have a special meeting with the current set of local government officials of the municipality of Los Bandidos in order to find out why they are not doing their job to clean up the pig industry. A consultation with the Baywatch Commission is also in order to find out why its Board Resolution has not achieved its aims.

This is the era of inclusive green growth, and the Secretary has made it clear that all of Piggylandia would like to have a share of the international market for pig meat output, especially as the country has been declared free of FMD by the Office International des Epizooties (World Organization for Animal Health [OIE]). Much is up for grabs.

In your consultation with the stakeholders present at the meeting, you need answers to the following important questions:

1. Why is BR No. 169 not effectively implemented? Can you identify the bottleneck?
2. Which option in the list will you recommend? Why do you think this recommendation will work now when it did not before?
3. How do you design an incentive mechanism that will induce pig farmers to "rise to the top"? "Rise to the top" means encouraging pig farmers to engage in best practice in order to clean up production and then receiving green certification/ecolabels for doing so. These ecolabels can fetch premiums in the market for their produce. Other ways to "rise to the top" are
    a. for backyard pig farmers to organize a cooperative that encourages members to minimize or treat pig waste as a way to address nonpoint sources of pollution,
    b. establishing clean and green abattoirs that only accept pigs for slaughter that are raised in environment-friendly manner, and
    c. moral suasion educating consumers to buy "green" pork.

Note: Role-playing this case study can be a more fun way to engage in discussions about decision making.

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Cassava starch processing near Hanoi, Vietnam. Photo by Neil Palmer (CIAT) under creative commons license www.flickr.com/photos/ciat/4070333241

# Which Option for Wastewater Treatment in an Agro-processing Village in Vietnam?

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Based on EEPSEA Research Report No. 2009-RR4: *Pollution control options for handicraft villages: The case of Duong Lieu village in the Red River Delta, Vietnam* by Nguyen Mau Dung and Tran Thi Thu Ha

*This case study highlights the complexities of mitigating pollution caused by wastewater in an agro-processing village in Vietnam. Three different options for wastewater treatment are addressed in this study, and case users are encouraged to discuss how to select a relevant option, while taking into account the trade-offs between the options in terms of their socioeconomic, environmental, and political implications. Although this case study is within the context of wastewater treatment in an agro-processing village in Vietnam, similar environmental problems can be found all over the world.*

*This case study can be used to encourage discussions about externality, the benefits of pollution mitigation, the trade-offs between pollution-mitigation options, and their differing levels of social acceptability. Although economic analysis is important to find sound cost-effective options, social and political factors also need to be considered when making decisions. Case users can be decision makers with mandates related to environmental management or local government, nongovernmental organizations working with local people on environmental issues, and lecturers working in areas related to environmental management. Members of discussion groups working on this case study should have a background in environmental economics or in public policy, economic analysis skills, and a sound understanding of social, cultural, environmental, and political factors.*

## Introduction

Duong Lieu is a famous agro-processing handicraft village in the Red River Delta (RRD) that mainly processes cassava to make starch. Around 500 households in the village (about 25%) are involved in this activity, and the total output of cassava starch exceeds 60,000 metric tons (t) per year. Although agro-product processing in Duong Lieu village significantly improves household income, it causes serious pollution in the village. The residents of Duong Lieu village understand that the wastewater from agro-product processing is an environmental health hazard that needs to be addressed (Dai, Do, and Dang 2000). Moreover, the pollution situation in the village has been highlighted many times by the local authorities and the mass media (Ha Tay Department of Industry 2001).

The People's Committee of Duong Lieu village is now seeking a way to make the village's agro-processing activities exist alongside environmental protection. A number of meetings between a technical consultation group (TCG) and the local population have been organized to propose solutions. These meetings have resulted in three possible options for pollution control: (1) installing a small wastewater treatment plant for every processing household, (2) building a treatment plant for a group of nearby processing households, and (3) establishing a treatment plant for the whole village. Villagers are currently considering which option should be selected.

Mr. Y, one of the village vice presidents, is the person responsible for making the final decision on which option should be selected. Mr. Y is currently one of the candidates standing for president of the village in the next election, which would be in two years time. The support of villagers and local staff is important to him, and his choice of option would probably influence people's support for him in the next election.

## Agro-processing Activities in Duong Lieu

Handicraft villages[1] are a common feature of rural Vietnam, most of which (around 60%) are located in RRD where cropland per farm is very small compared with other areas of the country. Of these, agro-product processing is a major activity, accounting for 15.7% of the total number of handicraft villages in the region (Nguyen and Tran 2009). Duong Lieu is one of the better-known agro-processing villages because it has been established for more than 30 years and has a huge output capacity.

Duong Lieu village has a total natural area of 410 hectares (ha) and its population is around 12,000, with a growth rate of 1.7% a year (Duong Lieu Commune People's Committee 2005). There are 2,680 households in Duong Lieu distributed across 12 hamlets. Many households in the village engage in non-agricultural activities, of which cassava processing is the leading one. Apart from the 25% of households directly engaged in cassava starch processing, approximately 6% are involved in cassava starch refiltering, 3% in cleaning services and peeling, 2% in cassava root trading, and around 1% in cassava solid waste trading. Agro-processing has created around 7,500 employment opportunities for the locals and also 300–500 employment opportunities for outsiders. Agro-processing contributes around 50% of the total gross output value of the village and is the main income source (accounting for 30%–60% of the total income of around VND 40 million a year) for many households in the village.

Despite these achievements, agro-product processing in Duong Lieu is carried out at the household level with very small processing areas. According to a research by the Economy and Environment Program for Southeast Asia (EEPSEA) in 2009, all the craft households carry out processing activities within their residential areas. The processing area is used for cleaning, peeling, and grinding roots, and accommodates several tanks to deposit the starch in. The processing area of households is between 10 and 100 square meters, depending on the

[1] *Such villages have a high concentration of households (typically over 30%) involved in the same kind of production activities.*

processing scale of the household. Processing and its associated work are mainly done using family labor. Most households own machines used in cassava processing (including cleaning and grinding machines, stirring machines, and "combinative" machines). Processing activities take place from September to March when the cassava roots are harvested. On the average, one household can process around 1 t of cassava starch a day.

## Waste Generated

Although cassava-processing activities help Duong Lieu households to earn considerably higher incomes and contribute greatly to the village's economic development, they generate a considerable amount of waste, mainly solid waste and wastewater. The processing of 1 t of fresh cassava roots requires 5.5–6.5 cubic meter ($m^3$) of water and generates 450–470 kilograms (kg) of wet cassava starch product. Processing of 1 t of fresh cassava root also discharges 50 kg of cassava peel and sand, 350–420 kg of wet solid cassava waste, 60 kg of wet black starch, and 5.05–6.3 $m^3$ of wastewater (Table 1).

**Table 1. Material inputs, outputs, and waste for processing 1 t of cassava root**

| Processing Stage | Inputs | Outputs | Waste |
|---|---|---|---|
| 1. Cleaning and peeling | + 1000 kg of cassava root<br>+ 0.8–1.2 $m^3$ of water<br>+ 1.5 Kwh of electricity | + 950 kg of peeled cassava root | + 0.8–1.2 $m^3$ of wastewater<br>+ 50 kg of peel and sand |
| 2. Soaking | + 950 kg of peeled cassava<br>+ 0.5 $m^3$ of water | + 950 kg of peeled cassava root | + 0.5 $m^3$ of wastewater |
| 3. Grinding | + 950 kg of peeled cassava<br>+ 2.5 Kwh of electricity | + 950 kg of very wet cassava starch (W = 68%) | |
| 4. Filtering the solid waste | + 950 kg of very wet cassava starch (W = 68%)<br>+ 4–5 $m^3$ of water<br>+ 2.5 Kwh of electricity | + Starch milk | + 3.8–4.8 $m^3$ of wastewater<br>+ 404 kg of wet solid waste |
| 5. Filtering the cassava starch | + Starch milk | + 500–520 kg of wet cassava starch (W =55%) | + 60 kg of black starch (W = 70%) |
| 6. Drying the cassava starch | + 500–520 kg of wet cassava starch (W =55%)<br>+ 30 kg of coal residuals | + 450–470 kg of cassava starch (W = 50%) | + 80 kg of wet coal residuals |

*Note:* W = degree of wetness or the percentage of water in the starch

The solid wet cassava waste/residue is sold to several companies to produce animal feed, and the wet black starch is used by households to feed pigs or is sold to other pig-raising households in or nearby village/s. Only the wastewater from the processing is freely discharged into village drains without any treatment. Therefore, wastewater is the principal source of environmental pollution and is a health hazard for local and neighboring communities.

## Wastewater Pollution

On the average, one small-scale processing household discharges nearly 10 $m^3$ of wastewater per day, while medium- and large-scale households discharge between 12.3 $m^3$ and 21.8 $m^3$ of wastewater a day. Surveys by the University of Technology in 2003 found that the concentrations of chemical oxygen demand (COD), biochemical oxygen demand (BOD), and total suspended solids (TSS) in wastewater in all of the processing steps were over the standards. These effluents were especially high in wastewater separated from deposited starch. Moreover, the effluents (COD, BOD) in the wastewater from cleaning and soaking were around 10–12 times higher than the standard. The wastewater from the starch deposition process had COD and BOD concentrations over 120 times higher than the standard.

The free discharge of wastewater, especially wastewater from the starch deposition process, without any treatment, causes serious environmental pollution in the village. The Duong Lieu People's Committee reported that environmental pollution has existed in Duong Lieu for a long time due to untreated wastewater from processing activities. However, the *People Newspaper* reported that there still hasn't been any solution to the problem up to now. Village households are aware of the pollution caused by wastewater; 75% of the households surveyed in 2007 by EEPSEA knew that wastewater from cassava processing seriously polluted the environment (Nguyen and Tran 2009). Almost all the interviewees reported that the pond water in the village could not be used for cleaning and washing any longer. About 80% of villagers said that the water in the ponds during the processing seasons had been dirtier than during nonprocessing seasons.

Undoubtedly, the pollution caused by cassava-processing activities in the village has had negative impacts on the environment and on local people's health. Common ailments reported in Duong Lieu village are headaches (52%), backache (43%), respiratory diseases (38%), and skin irritation (36%). Stomach ache, conjunctivitis, and cancer are also common in the village. The incidence of illness in Duong Lieu village is often higher than that in other villages in the region. Residents in nearby communities have also complained about the wastewater from Duong Lieu village.

## Current Efforts

Due to the serious environmental consequences of agro-product processing in Duong Lieu, the local government and residents have adopted several measures to try to mitigate the pollution. The People's Committee issued environmental protection regulations in 2005, in which each person in the village has to contribute VND 3,000 a month to a village Environmental Sanitary Fund. In addition, each processing household has to contribute VND 50,000 a year to the fund. An environmental sanitation team was established who has become responsible for collecting domestic solid waste and cleaning village roads and drains. Each year, the village invests around VND 20 million toward the upkeep of the village drainage system. The drains were built in 1990, and are therefore old; they sometimes get clogged up with waste water and other wastes. Mass media dissemination and village meetings have also been undertaken to raise villagers' awareness of environmental protection.

Despite these efforts, pollution from wastewater discharge persists and is becoming more serious as processing volumes increase year-on-year. A number of residents in nearby communes who have been affected by Duong Lieu wastewater have sued the village over this pollution and demand that the local district authorities intervene. The newspaper in Ha Tay province has publicized the situation and demands solutions. Likewise, the residents of Duong Lieu village have appealed for solutions now that they understand the health hazards of the pollution.

## Pollution Control Options are Considered

With this demand for action, a TCG has been summoned to investigate and propose solutions to the pollution problems of Duong Lieu. Based on several meetings between the TCG and locals, three solutions are being considered.

***Option 1*** proposes establishing a small treatment system of 15 $m^3$ for every individual processing household at each household, with an initial investment cost of around VND 40 million (Table 2).

***Option 2*** proposes that the wastewater from a group of 10–15 processing households located near to each other will be collected for treatment by plants with a capacity of 200 $m^3$ per day. The initial investment for this option would be around VND 500 million per treatment plant established, which would be borne by the processing households being serviced.

***Option 3*** proposes establishing a treatment system for the whole village. All the wastewater from all the processing households outside the dike (around half of the total) would be collected into one common pool through the village drainage and canal system, while all the wastewater from the processing households inside the dike would be collected into another common pool in the village. A treatment plant with a capacity of 2,500 $m^3$ would be established at each pool, with an initial investment of around VND 3.5 billion for each plant.

**Table 2. Cost estimates for the three pollution control options**

| Cost Items | Cost ('000 VND) | Details |
|---|---|---|
| 1. Option 1: Small treatment system for an individual household (15 $m^3$ per day) | | |
| Plant construction | 34,918.00 | The treatment plant can last for 15 years. |
| Equipment | 8,216.00 | The equipment can last for five years. |
| Reagents | 1.88 | This reagent cost is for daily treatment of 15 $m^3$. |
| Electricity | 2.40 | This electricity cost is for daily treatment of 15 $m^3$. |
| Labor | 100.00 | This is the monthly labor cost (30 days) for plant operation and management. |
| 2. Option 2: Treatment system for a household group (200 $m^3$ per day) | | |
| Plant construction | 139,932.00 | The treatment plant can last for 20 years. |
| Equipment | 376,425.00 | The equipment can last for five years. |

*Table 2 continued*

| Cost Items | Cost ('000 VND) | Details |
|---|---|---|
| Reagents | 100.10 | This reagent cost is for daily treatment of 200 $m^3$. |
| Electricity | 292.00 | This electricity cost is for daily treatment of 200 $m^3$. |
| Labor | 1,400.00 | This is the monthly labor cost (30 days) for plant operation and management. |
| 3. Option 3: Treatment system for a whole village (2,500 $m^3$ per day) | | |
| Plant construction | 2,110,611.00 | The treatment plant can last for 20 years. |
| Equipment | 1,386,000.00 | The equipment can last for five years. |
| Reagents | 1,251.50 | This reagent cost is for daily treatment of 2,500 $m^3$. |
| Electricity | 1,402.00 | This electricity cost is for daily treatment. |
| Labor | 7,200.00 | This is the monthly labor cost (30 days) for plant operation and management. |

*Source:* Estimated by the technical expert

Several meetings between processing households, local staff, and the TCG have been organized to discuss the options. Although all of the households agree that it is necessary to do something to mitigate pollution, most of them express concern regarding the cost of establishing the treatment system. Meanwhile, households have recently faced greater difficulties in their processing businesses due to fiercer competition, higher input costs, and unstable output prices. A high investment cost for a treatment system will increase their financial burden and make it more difficult for them to do business, particularly for poor processing households.

As has been agreed in recent meetings, any option that is selected will have 50% of its investment cost funded by the village committee, while the other half will be covered via the contribution of serviced processing households. The village plan to design and submit the best option to the provincial DOST (Department of Science and Technology) with the aim of obtaining around VND 5 billion from DOST. The probability of being awarded this money is quite high as DOST is trying to build a model for mitigating pollution in craft villages, which is often highlighted in fierce debates broadcast via the mass media.

A small research project on the cost-effectiveness and social acceptability of these options has recently been undertaken by EEPSEA researchers. According to the research results, the average treatment cost for 1 $m^3$ of wastewater was the lowest in Option 1, followed by Option 3, and Option 2. Fifteen local people have been invited by EEPSEA researchers to discuss the social acceptability of each option, with help from the TCG and the researchers. These discussions show that Option 1 is the easiest option for individual households to manage and operate. However, the disadvantages of the treatment system outlined in Option 1 are limited space for plant construction at each household, low cultural acceptability, and the short lifespan of the onsite (household) treatment plant. The advantages of Option 2 are the long lifespan of the treatment system and the use of the existing drainage and canal in

the village. However, the difficulty of finding space to install the system, high investment costs, low levels of cultural acceptability, and the high level of technical support required are this option's disadvantages. Option 3 offers several advantages such as its high level of cultural acceptability; use of the existing drainage, canal, and common pool system in the village; and the fact that there is space available to site the treatment plant. However, the significant level of technical expertise required is a disadvantage. In addition, according to the technical group, although the household treatment system can be quickly constructed and put into operation, establishing group-household treatment system and the common treatment system will take much longer.

## Your Assignment

Complaints from non-processing households in Duong Lieu and from people in nearby villages regarding the serious pollution created by agro-processing in Duong Lieu, combined with reports of this situation in the mass media, have put Duong Lieu village committee under pressure to take action. Mr. Y, as the person responsible for this issue in the village, would like to implement Option 1.

You are Mr. Y's technical consultant and you are asked to review the three options in order to help Mr. Y fully consider the following:

1. What should be considered when selecting treatment options?
2. Which option should Mr. Y select for implementation?
3. What action should be taken to reduce immediately the pressure on the pollution situation in the village?

Your assignment is to prepare the key messages that you wish to present to Mr. Y so that he can make the best final decision.

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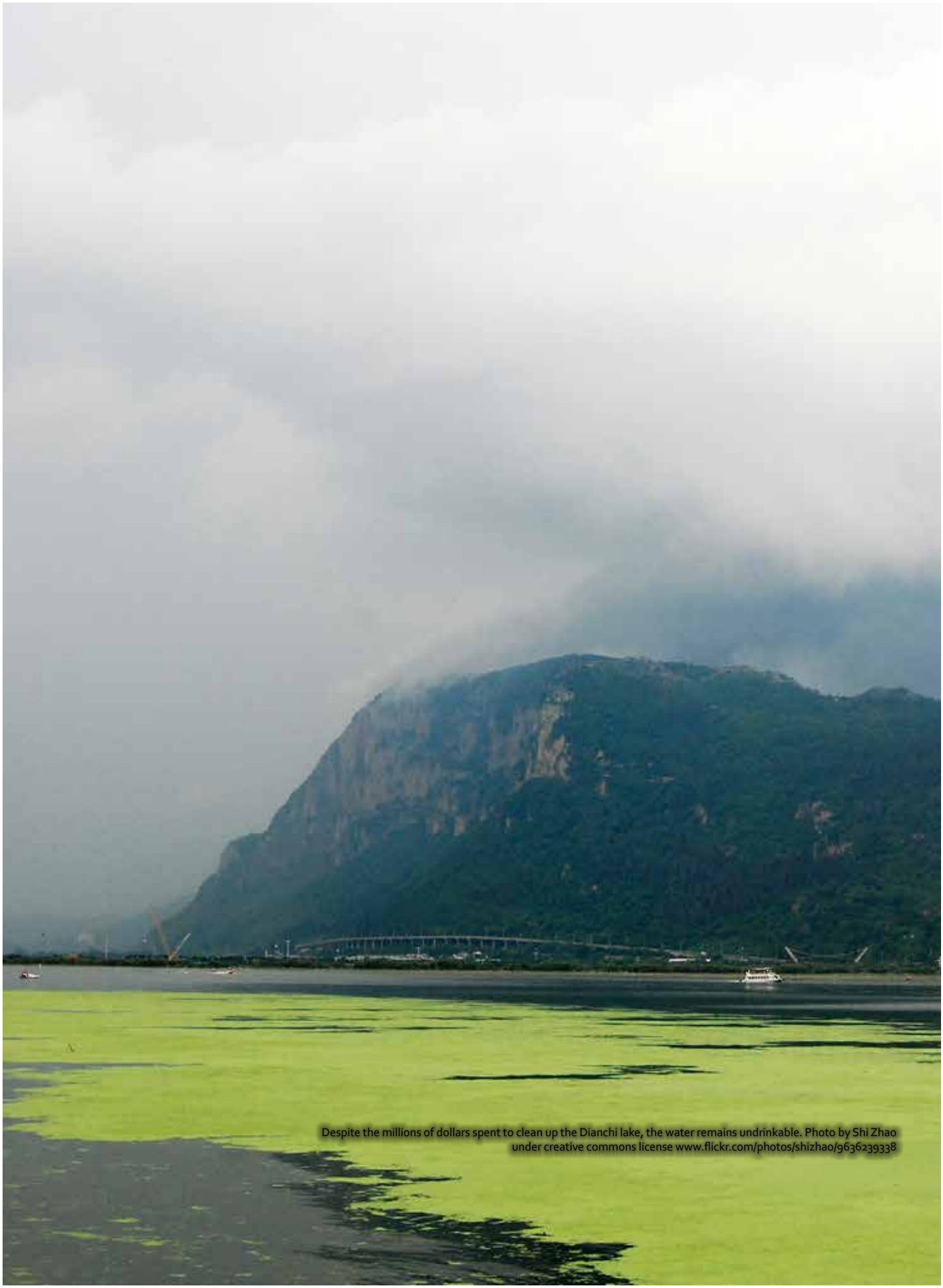

Despite the millions of dollars spent to clean up the Dianchi lake, the water remains undrinkable. Photo by Shi Zhao under creative commons license www.flickr.com/photos/shizhao/963623933 8

# Water Pollution in China

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Based on EEPSEA Research Report No. 2013-RR7: *An economic analysis of the use of water hyacinth for phytoremediation and biogas production in Dianchi Lake, China* by Wang Zanxin and Wan Jin

*Surface water pollution and the associated spread of water hyacinth is an environmental problem in China that needs to be dealt with more effectively. This case study presents details of a project to achieve improvements in water quality, the control of water hyacinth, and the production of biogas. The proposed project is economically feasible but financially unfeasible. The implementation of the project requires a specific policy that can address all three of the above objectives.*

*This case study is suitable for use by lake or river management authorities, environmental protection authorities, biogas producers, local development and reform commissions, and students of resource and environmental economics.*

## Background

Dianchi Lake is situated on the south of Kunming City, Yunnan province, China. Not only is it the water source for agriculture, industry, households, and fisheries in Kunming, it also serves as a sink for urban sewage, industrial wastewater, and agricultural runoff. The water quality in the lake used to be Level II, or drinkable with regular treatment, according to China's surface water quality standards (GB3838-2002). Beginning in the late 1980s, the water quality decreased sharply as a result of economic development. The lake is now suffering from eutrophication and has a water quality of Level V, which means it is undrinkable without intense purification. The nitrogen and phosphorus contents of Dianchi Lake have stayed at the level of 1.82–3.31 milligram per liter (mg/l) and 0.131–0.640 mg/l, respectively, for several years (Deng 1998; Zhang 2007). Although many measures have been implemented, the eutrophication of Dianchi Lake has not been successfully reduced (Zhang 2007). The lake can no longer supply drinking water to the city, and thus Kunming City has to resort to other water sources.

Water hyacinth has thrived alongside the eutrophication of Dianchi Lake owing to its capacity to multiply and spread rapidly (Gopal 1987; Mehra et al. 1999). It is one of the most productive plants on earth (Gopal 1984; Malik 2007). The doubling time for water hyacinth varies from 6 to 28 days for weight, and from 4 to 58 days for number of plants measured in the open (outside ponds) or in the field (Gopal 1987). A mat of medium-sized plants may contain 2 million plants per hectare that weigh 270–400 metric tons (t) (Epstein 1998). The rapid proliferation of water hyacinth can have detrimental effects, including exhausting the oxygen in water and interfering with navigation, recreation, irrigation, and power generation; this, in turn, may have negative effects on the environment, human health, and economic development (Mehra et al. 1999; Epstein 1998).

At present, there are several different methods used to manage water hyacinth, including physical removal by harvesters, biological control, and the application of herbicides. Physical control is expensive and is not always feasible because a lot of labor and a convoy of water- and land-based vehicles are required to transport harvested mats; the application of herbicides is expensive and has long-term adverse effects on other communities and the environment; and biological control is still in the research and development stage and may not suffice alone (Malik 2007).

Currently, water hyacinth is removed mechanically, and the collected biomass is disposed of via landfill (without-project scenario). The average annual growth of water hyacinth is 250,000 t. From 2005 to 2010, the Dianchi Administration Bureau (DAB), the authority of Dianchi Lake, paid eight companies to remove 820,000 t of water hyacinth from the lake. Because water hyacinth is hardy and reproduces rapidly, controlling the weed is expensive and removal is usually only temporary (Gunnarsson and Petersen 2007). The effective control of water hyacinth requires an economically viable solution (Mara 1976). Proper and large-scale utilization of water hyacinth could serve as one such positive approach.

Water hyacinth could be used to absorb nutrients from the body of water it inhabits, and its biomass could then be used to produce biogas. It can take away the nutrients from a water body, thereby contributing to water quality improvement. It can also effectively remove nitrogen and phosphorus from water, and absorb contaminants such as metals that cannot be easily biodegraded for recycling, among others (Maine, Sune, and Lagger 2004; Malik 2007). However, this purification effect can only be achieved if the water hyacinth is taken away from the body of water—otherwise, what has been absorbed will go back into the water as it decays. Due to its high water content and an appropriate carbon/nitrogen (C/N) ratio, water hyacinth can also be used to produce biogas through anaerobic digestion (Singhal and Rai 2003). This combined use of water hyacinth could thus offer a sustainable system (Malik 2007).

Despite its technical viability, using water hyacinth to phytoremediate eutrophic water and produce biogas is not yet applicable. From a social perspective, one of the principal barriers to the integrated model system is that the environmental benefit is not well-recognized. With this, policies are needed to internalize the environmental benefits of bioenergy and water quality improvement so that biogas from water hyacinth can become competitive with fossil fuels.

The project *An Economic Analysis of the Use of Water Hyacinth for Phytoremediation and Biogas Production in Dianchi Lake, China* funded by the Economy and Environment Program for Southeast Asia (EEPSEA) was conducted to assess the financial and economic feasibility of a proposed project to use water hyacinth to purify water and make biogas (with-project scenario). The production process of this project was composed of several stages:

1. collection of water hyacinth
2. pretreatment of raw materials
3. hydrolysis and acidification
4. anaerobic digestion
5. production of organic fertilizer
6. purification and storage of biogas
7. transportation and distribution of products

It was assumed that the project would have a lifespan of 15 years (linked to the lifespan of the machinery and equipment of the biogas plant), and the production system would have a daily processing capacity of 10 t of water hyacinth, a daily production capacity of 150 cubic meter of biogas, and 12 t of liquid manure (which is a by-product of the biogas plant). Using a discount rate of 6%, the economic results of the project are shown in Table 1.

**Table 1. Results of economic analysis**

| Component | Without Project (0) (million CNY) | With Project (1) (million CNY) |
|---|---|---|
| Benefits | | |
| Benefit of biogas | | 6.21 |
| Value of GHG emissions reduction | | 0.47 |
| Benefit of organic fertilizers | | 2.16 |
| Value of water quality improvement | 13.72 | 13.72 |
| Salvage value of fixed assets | | 0.56 |
| Subtotal (B) | 13.72 | 23.13 |
| Costs | | |
| Cost of collecting water hyacinth | 4.25 | 4.25 |
| Fixed costs (machinery and land rent) | | 3.14 |
| Workers' wages for disposing water hyacinth | 1.36 | 2.22 |
| Cost of the emissions of GHG, other than methane | 0.02 | 0.02 |
| Cost of methane emissions | 6.04 | |
| Cost of transport and land fill | 3.47 | 1.24 |
| Others (including land rent, electricity charges, repair and maintenance costs, and payment for passivation substance and alkali) | 0.002 | 0.50 |
| Subtotal (C) | 15.56 | 11.40 |
| **Economic gain [E(i) = B(i) – C(i)]** | **–1.42** | **11.72** |
| **ENPV [E(1) – E(0)]** | **13.14** | |

The results revealed that the project is economically feasible but not financially feasible. However, to achieve the same level of control over water hyacinth as in the without-project scenario, the government would spend less money on the control of water hyacinth if they were to implement the proposed project. In order for firms to breakeven, the municipal government would have to pay CNY 104.8/t of disposed water hyacinth in the without-project scenario, but would pay only CNY 66.8/t in the with-project scenario.

Compared to the project, the current methods of controlling the spread of water hyacinth have two major disadvantages. First, the biomass of water hyacinth is not used but is disposed of as waste—the proposed project offers a way for the biomass of water hyacinth to be utilized. Second, landfill gas emissions are ignored, and they enter the atmosphere due to the absence of a gas capture system; thus, increasing greenhouse gas (GHG) stock in the atmosphere. As an alternative to the current approach, the proposed project would reduce methane emissions.

The proposed project is desirable in terms of energy performance—disposing of 11,004.2 t of water hyacinth achieves an energy gain of 5.3 trillion joules; the current approach has an energy loss of 162.9 billion joules. The proposed project can also reduce GHG emissions—annual consumption of 11,004.2 t of water hyacinth can equate to a reduction of 3,921.5 t of carbon dioxide equivalent per year. The value of this is CNY 0.36 million per year using the price of Certified Emission Reduction (CER) in the Clean Development Market (CDM) in China in 2011. Thus, the production of biogas from water hyacinth is a potential CDM project.

Compared to current practice, additional value depends on the scale of processing at the biogas plant. If the scale of processing is less than or equal to the current amount of water hyacinth that is removed (i.e., 164,000 t), the project has no additional value beyond that of an improvement in water quality; but it can avoid the current economic losses incurred by methane emissions. If the scale of processing is greater than 164,000 t, then processing each additional unit of water hyacinth has a corresponding additional value of improvement in water quality but no more additional avoided loss from methane emissions. To achieve the same level of control over water hyacinth using the current practice, the project needs to process 164,000 t of water hyacinth. However, considering the annual rate of growth in water hyacinth of around 250,000 t, there are significant opportunities for expanding the scale of biogas production.

These results have strong policy implications. First, the proposed project offers a better policy option than the current approach of disposing water hyacinth via landfill in terms of both environmental and economic performance. Second, the project can be a potential response to China's policies on water pollution control, renewable energy development, and energy saving and emission reduction. However, to achieve the combined objectives of water quality improvement, water hyacinth control, and renewable energy production, it requires specific institutional arrangements, which are more complex to implement than the current approach.

## Dianchi Administration Bureau's Problem

Both the improvement of water quality and the production of biomass gas fall within the framework of China's related policies. On one hand, water pollution control and water quality improvement are highlighted in the Law of Water Pollution Control and the 12th Five-Year National Plan for Environmental Protection. In particular, the Chinese Central Government has designated Dianchi Lake as one of three lakes (Taihu, Caohu, and Dianchi) with national priority for treatment and restoration. On the other hand, the Chinese government has adopted many policies and measures to develop renewable energy and address the issue of climate change. The Energy Conservation Law, Renewable Energy Law, and the 11th Five-Year Plan for the Development of Renewable Energy have provided a solid foundation for the development of renewable energy, including biomass gas. In order to reduce carbon emissions, the Chinese government had formulated and issued the National Assessment Report on Climate Change in 2006 and China's National Climate Change Program in 2007. All of these policies are the concerns of the Kunming Development and Reform Commission (KDRC).

As water quality continues to worsen and water hyacinth continues to spread, DAB has to apply for funding from the KDRC to support an initiative to improve water quality and to control the

growth of water hyacinth. Knowing that the collected water hyacinth can be used to produce biogas, KDRC now faces two options for funding:

***Option 1:*** Funding is continuously provided for the current approach, namely, water hyacinth is removed and disposed by landfill; and

***Option 2:*** Funding is provided for the proposed project, that is, water hyacinth is removed and used to produce biogas.

## Your Assignment

An expert panel is assembled to discuss which of the above options should be chosen. You are invited to become a member of the panel as a representative of experts in natural resources and environmental economics.

KDRC is seeking advice on the following:

1. What criteria should be used to make the choice of option?
2. How should the criteria be prioritized?

Your assignment is to prepare the key messages that you wish to convey to the expert panel.

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Tianjin Integrated Gasification Combined Cycle Power Plant. New technology for generating power by using coal in a cleaner and more efficient way. Photo by Asian Development Bank under creative commons license at www.flickr.com/photos/asiandevelopmentbank/19950287032

# 4

# Energy, Biofuels, and Fuel Subsidy

Local firewood store. Photo by shankar s.
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# Options to Reduce the Environmental and Economic Costs of Energy Consumption in Rural Households

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Based on the EEPSEA-funded research *Fuelwood consumption patterns in Chumriey Mountain, Kampong Chhnang province, Cambodia* by San Vibol, Spoann Vin, Ly Dalin, and Cheng Veng Chheng Ngov as published in Energy 44 (2012): 335–346

*This case study looks at the dominance of fuelwood as the main energy source for people living in rural Cambodia. Fuelwood is used for several purposes such as cooking, boiling water, preparing pig feed, protecting animals against insects, and producing palm sugar. Fuelwood is heavily harvested from natural forest, which is illegal by Cambodian law. In rural areas, when wood is harvested in an unsustainable way to meet people's energy demands and inefficient conversion technologies are used, a series of health, environmental and economic problems are the result. In an attempt to tackle issues of this kind, several projects and activities to improve the efficient use of fuelwood have been implemented, but energy consumption patterns have not significantly changed so far. Therefore, four energy consumption options based on environmental and economic cost analysis are proposed for rural areas. These options are*

- *Option 1: the present energy structure with biomass energy as the dominant energy source (status quo),*
- *Option 2: an energy structure with fossil fuel as the dominant energy source,*
- *Option 3: the exclusive use of electricity, and*
- *Option 4: biogas as the energy structure.*

*Participants should be divided into four different groups to discuss these options.*

## Introduction

In Cambodia, around 80.5% of the total population is in the rural areas (2.3 million households or 81.7%) and 19.5% of the population live in urban areas (0.5 million households or 18.3%). The average size of a household is 4.7 people. Fuelwood is the most common source of energy for the majority of the population in the Kingdom of Cambodia. Fuelwood is often referred to as a traditional fuel, yet it remains the dominant source of energy for cooking, boiling water, preparing animal feed, and protecting cattle against insects within the domestic sector; it is used extensively by industry and services.

The Statistical Yearbook for 2008, published by the National Institute of Statistics of Cambodia, reported that 85% of Cambodian households in 2007 had used fuelwood for cooking purposes. Charcoal was used in 6% of households, followed by liquefied petroleum gas (LPG) (5.2%), publicly provided electricity/city power (0.2%), and kerosene (0.02%). Around 98.2% of rural households used fuelwood and charcoal. Approximately 31.2% and 87.0% used fuelwood and charcoal in Phnom Penh and other urban areas, respectively. Usually, fuelwood is collected from forests; this makes forests an important resource for sustainable development in Cambodia.

In addition to cooking, fuelwood is used to produce charcoal and for burning to evaporate palm juice to produce palm sugar. The demand generated by the nation's capital alone for charcoal consumes some 600,000 metric tons (t) of wood per year, with 30% of Phnom Penh's population of over 2 million relying on charcoal for their energy needs. For producing palm sugar, traditional palm sugar production needs around 144,000 t of fuelwood annually, the second-highest usage after domestic cooking, and 20,000 families are involved in palm sugar production, mostly in rural areas.

Forest cover in Cambodia has declined from 11.3 million hectares (ha) or 61% in 2002 to 10.9 million ha or 59% in 2006; the net annual rate of deforestation is estimated at 0.5%. The changes in forest cover in Cambodia are related to population growth. Rapid increase in population has led to an increase in the demand for fuelwood and agricultural land. It has been identified that fuelwood collection and consumption is one of the main drivers of deforestation. With more stringent laws coming into place, 100% of the wood consumed from these types of activities comes from illegal harvesting of natural forests. Wood is extracted to feed kilns, hidden from forest rangers and the police, that produce charcoal, which is an activity operated by poor communities that rely on this destructive industry for up to 50% of their income. These practices have severe environmental and socioeconomic consequences, which exacerbate the development challenges Cambodia faces.

Even though efforts have been made to promote new efficient stoves and kilns and renewable energy (i.e., biogas and solar energy), many people (mostly in rural areas) still depend on fuelwood for their main energy source and use inefficient stoves and charcoal kilns.

## Background to Fuelwood Consumption and Deforestation

A research in 2010 funded by the Economy and Environment Program for Southeast Asia was conducted to investigate fuelwood consumption and sources for activities such as cooking, boiling water, preparing pig feed, producing smoke to protect cattle against insects, producing palm sugar, and making charcoal. The study was carried out in the Chumriey Mountain area, which is located in Sameakki Mean Chey (Figure 1). The Chumriey Mountain area has 40,496 ha of forest cover and is dominated by two forest types: mixed/semi-deciduous (at the top of the mountain) and deciduous. It also serves as a buffer zone for the Aural Wildlife Sanctuary. The Chumriey Mountain area is one of the main fuelwood and charcoal sources for the city of Phnom Penh. Therefore, fuelwood and charcoal production are the main income sources for people in the area as well as the main sources of energy.


**Figure 1. Map of study location**

The study found that most rural households in the study area remain in a state of energy poverty. They use a variety of nonconventional energy sources, including traditional biomass (e.g., fuelwood, plant waste, etc.); kerosene; and even LPG. Approximately 96% of households use fuelwood to prepare food and boil water every day; 12.4% of families use charcoal in addition to fuelwood when grilling meat or fish. Only 6.6% of households use crop residue as an energy source.

Overall, average fuelwood consumption for cooking and boiling water is 5.21 ± 0.11 kilograms per day per family and 2.82 ±0 .11 kilograms per day per family, respectively. Other activities, such as preparing animal feed and protecting animals against insects, are performed everyday using fuelwood. Households with a high number of cattle or pigs consume a larger amount of firewood in order to make smoke, and accordingly protect their cattle against insects, or to prepare pig feed. The overall average firewood consumption rate is approximately 5.60 ± 0.11 kilograms per day per family for repelling insects, and 3.90±0.19 kilograms per day per family for preparing pig feed.

Kerosene is used as an energy source for lighting in 60.5% of the surveyed 767 households, rechargeable batteries are used in 57.9% of households, and electricity in 5.1% of households. Lamps fueled by kerosene are used by households without access to the electricity grid or rechargeable batteries. Kerosene is used for lighting at night, and the average consumption rate per family per month is 1.99 ± 0.17 liter (l) (1.63 ± 0.14 kilograms [kg]) (Table 1).

Although most households without access to the electricity grid or rechargeable batteries use kerosene for lighting, rechargeable batteries are the main energy source for lighting and for running devices such as televisions and music systems. People living in the rural areas usually use 12 volt rechargeable batteries with 50 Ampere-hour. These batteries are usually recharged five or six times a month. The average amount of electricity generation by rechargeable battery per month is 3.3±0.1 kilowatt hour (kWh). Households that use rechargeable batteries often also use small amounts of kerosene for lighting.

The study also reported that 97% of the sampled households obtain fuelwood by collecting it from various sources, while only 3% of the sampled households purchase fuelwood from fuelwood sellers in their village. Six different sources of fuelwood for daily consumption were identified in the study area, namely, natural forest, scrubland, wasteland, agricultural plantations, hedges, and homesteads. The study revealed that 49% of families obtain fuelwood from natural forest and 18% obtain it from scrubland.

**Table 1. Rural energy consumption per family per month**

| Energy Use | Fuelwood | LPG | Electricity | Biogas | Kerosene | Batteries |
|---|---|---|---|---|---|---|
| Cooking | 156.11±3.38* | 4.88±1.25 | 0.00 | 60 | 0.00 | 0.00 |
| Boiling water | 84.72±3.19* | – | 0.00 | – | 0.00 | 0.00 |
| Preparing animal food | 117±5.59* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Protecting animals against insects | 167.9±3.34* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lighting | 0.00 | 0.00 | 22.17±2.73 | – | 1.63±0.14 | 3.3±0.1 |
| Electrical appliances | 0.00 | 0.00 | – | 0.00 | 0.00 | – |

*Notes:* (1) The unit of fuelwood is kilograms (kg); electricity, kilowatt-hour (kWh); LPG, kg; biogas, cubic meter ($m^3$); kerosene, kg; battery, kWh. (2) Density of kerosene = 0.82 kilograms per liter (kg/l).

## Policy Options

In order to help the poor and to reduce the negative impacts on the environment, four policy options are proposed that are based on environmental and economic cost analysis.

***Option 1: The present energy structure with biomass energy as the dominant energy source (status quo)***

The current energy structure is inconvenient to households due to its impact on human health and the environment, as well as the time that has to be spent collecting and chipping fuelwood. Fuelwood is obtained mainly from natural forests, so the collection of fuelwood can cause deforestation.

Likewise, burning firewood and charcoal produces large amounts of carbon dioxide ($CO_2$), but the emissions from fuelwood consumption are considered to be carbon neutral if the fuelwood is harvested sustainably. In addition, it clearly indicates that under the current energy structures, with biomass energy as the dominant energy source, cash payment is low while the environmental cost is the highest (Table 2).

***Option 2: An energy structure with fossil fuel as the dominant energy source***

The energy structure is comprised of LPG, kerosene, and batteries. LPG is a suitable replacement for fuelwood but the price is high at USD 1/kg, and it is not widely available in rural areas. Some households need to travel several kilometers to buy LPG. Note that the availability of energy sources and the income of the household members come into play when determining the specific energy mix of a household. Table 2 indicates that environmental cost is lowest at USD 0.03 when fossil fuel is used as a substitute for biomass energy. In addition, cash payments are much higher.

**Table 2. Monthly environmental and economic costs using different energy structures**

| Energy Use | Economic Costs (USD) | Environment Costs (USD) | Total Cost (USD) |
|---|---|---|---|
| Present structure | | | |
| Without electricity | 19.11 | 0.32 | 19.43 |
| With electricity | 33.23 | 0.23 | 33.46 |
| Fossil fuel dominating | 25.00 | 0.03 | 25.03 |
| Exclusive use of electricity | 186.80 | 0.00 | 186.80 |
| Exclusive use of biogas | 5.37 | 0.04 | 5.41 |

***Option 3: The exclusive use of electricity***

Electricity can be a substitute for all other energy sources. Electricity provides a simple structure, and it is a clean and convenient energy source for households. However, using the current price per kWh (USD 0.675/kWh) in the study area in 2012, the monthly economic cost is the highest of all the options at USD 186.8 per household.

Furthermore, the whole amount requires cash payment. A monthly cost of USD 186.8 per household (at the current price) is higher than the total monthly income of rural households. Rural households cannot pay such an amount. Likewise, majority of the households in the study area cannot access electricity because the electricity grid is not available where they live. However, it should be considered that electricity consumption does not bring an environmental cost, whereas thermal power generation does.

***Option 4: Biogas as the energy source***

Biogas is used for cooking, boiling water, and lighting but not for electrical home appliances. Biogas can be a substitute to major biomass energy. However, a small amount of charcoal is occasionally still required for smoking fish or meat. Other energy sources are still needed such as batteries for electrical home appliances and kerosene for lighting on weekly holy days and when gas from biogas runs out. This energy structure comprises kerosene, biogas, and batteries.

Using biogas as energy source is more convenient than the present structure, more environmentally friendly, healthier and safer, and can reduce greenhouse gas emissions. The monthly economic cost and total cost are the lowest if compared to the other structures, being USD 5.37 per household and USD 5.42 per household, respectively. The monthly environmental cost is also much lower at USD 0.04 per household (Table 2).

## Your Assignment

The case study participants come from four different groups, namely,

1. the local community,
2. the Forestry Administration (FA),
3. the Ministry of Mines and Energy (MME), and
4. the Ministry of Environment (MoE).

You are presenting to the Minister of MME, the Minister of MoE, and the Director of FA. You are asked to recommend an option to these officials based on the results of the EEPSEA research outlined in this case study. Ask yourself the following questions:

1. Which option do you recommend? Why?
2. What kind of activities should be taken to promote the option you recommend?
3. What are the risks and assumptions of implementing the option you propose?
4. How effective is your option?


Coal-fired electric plant, Henan Province, China. Photo by V.T. Polywoda
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# Substituting Natural Gas for Coal: Is This a Good Choice for China?

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Based on EEPSEA Research Report No. 2001-RR14: *Improving air quality in Chinese cities by substituting natural gas for coal: Barriers and incentive policies* by Mao Xianqiang and Guo Xiurui

*Chinese cities face serious air pollution caused by the burning of coal. Substituting natural gas for coal appears to be an attractive solution to this problem. However, economic and noneconomic barriers, competing uses for natural gas, and competing pollution reduction strategies bring into question this fuel substitution, making it a controversial issue. This case study tries to mimic in part a decision-making situation regarding the use of coal or natural gas. The pros and cons of the choice are illustrated, and there is discussion of how to implement the chosen decision via different optional policy instruments.*

*This case study has been prepared for training courses oriented toward government decision makers (government officials). It is also suitable for use in graduate student courses such as natural resource management, economics and policy studies, and public policy. Participants should be encouraged to answer the assignment questions and be actively involved in discussion and debate.*

## Background

As a result of rapid economic development and the accompanying consumption of large volumes of coal, China has faced serious coal-smoke pollution in urban areas since the late 1990s. In large cities such as Beijing and Chongqing, people are suffering the adverse health effects of coal-smoke pollution, with TSP (total suspended particulate) $PM_{10}$ (particulate matter less than 10 micrometer in diameter)[1] and $SO_2$ (sulfur dioxide) being the main pollutants.

At the time, natural gas (NG), which has never been the dominant energy source in China, was becoming one of the most attractive and promising clean substitutes for coal to reduce air pollution. However, high-ranking officials in the National Development and Reform Commission (NDRC) found themselves in a dilemma. Although China did not announce a formal NG utilization policy before 2007, NG was prioritized as a raw material for the chemical industry. The proportion of NG used for chemical fertilizer production was as high as 64.7% in 1991 (Wang 1993).

[1] *$PM_{2.5}$ was not a concern until 2011.*

As such, should this long-standing relationship between natural gas use and the chemicals industry be changed?

There was widespread disagreement about the rationality of burning natural gas instead of using it as a raw material for the chemical industry. It has been argued that the economic and resource feasibility of NG for household and heating use were not good. However, people also observed that the importance of NG as a raw material in chemical production was reducing, while resource availability was increasing. Finally, perhaps most importantly, NG seemed to offer a reduction in air pollution and environmental health benefits for large cities.

Given these considerations, should China substitute natural gas for coal?

1. If the answer to this question is "yes", what should be done?
2. If the answer to this question is "no", what should be done?

## Coal Consumption and Air Pollution

According to *The 2002 State Bulletin on China's Environment* (SEPA 2003), air pollution in China in 2002 resulted primarily from particulates. Certain cities suffered severe pollution from $SO_2$. $SO_2$ from discharged waste gas and smoke dust totaled 10,127,000 metric tons (t) and 19,266,000 t, respectively.

China's energy structure has been responsible for the country's serious air pollution problems. Some 90% of $SO_2$ emissions come from coal combustion and 73% of smoke dust from energy consumption. In most Chinese cities, coal is used for heating and cooking by residential and commercial consumers, causing much indoor and outdoor air pollution. In 2000, coal accounted for 67% of China's total primary energy consumption, compared to 23.6% for oil, 6.9% for hydroelectric power and nuclear power, and only 2.5% for natural gas. By contrast, in developed countries, coal accounted for just 22% of total energy consumption (Chen 1999), while NG accounted for over 26% (NBS 2001).

## The Health Consequences of Air Pollution

The main coal-smoke air pollutants are TSP/$PM_{10}$ and $SO_2$. These pollutants cause serious damages to human health and to other materials, and consequently result in economic loss. Although the results vary widely, a closer look at Table 1 reveals that, whether using the willingness to pay (WTP) valuation method or the human capital valuation method, the health damage caused by air pollution is clearly serious. According to a 1997 World Bank study-based valuation, in 1995, the annual loss from air pollution-caused health damages amounted to CNY 7,203 million in Beijing and CNY 3,347 million in Chongqing,[2] or 3.7% and 2.4% of the local GDP in these two cities, respectively.

[2] *These results were based on WTP valuation method.*

**Table 1. Estimated annual air pollution damage in Beijing and Chongqing (1998)**

| Valuation Study | Study Sites | Annual Loss (million CNY) | | Percentage of City's GDP | Estimated Damage from Polliution |
|---|---|---|---|---|---|
| World Bank (1997) study based valuation, (money in 1995 CNY, numbers in brackets have been adjusted to 1998 CNY by price index) | Beijing | WTP valuation | 7,203 (7,491) | 3.7 | Mortality; illness; restricted activity days; chronic bronchitis; other health effects |
| | | Human capital valuation | 2,510 (2,610) | 1.3 | |
| | Chongqing | WTP valuation | 3,347 (3,480) | 2.4 | |
| | | Human capital valuation | 1,166 (1,213) | 0.8 | |
| Calculated by the author based on the methods used by Ostro (1994, 1996) (money terms in 1998 CNY, with benefit-transfer method, WTP, and adjusted COI) | Beijing | Low value | 18,200 | 9.0 | Health damage caused by $PM_{10}$ and $SO_2$ |
| | | Central value | 75,400 | 37.4 | |
| | | High value | 223,000 | 110.9 | |
| | Chongqing | Low value | 5,030 | 3.5 | |
| | | Central value | 21,100 | 14.8 | |
| | | High value | 65,900 | 46.1 | |
| Calculated by the author based on the method used by Rowe, Lang, and Chestnut (1995), (money terms in 1998 CNY, with benefit- transfer method, WTP, and adjusted COI) | Beijing | Low value | 6,070 | 2.9 | Health damage caused by $PM_{10}$ |
| | | Central value | 21,100 | 10.2 | |
| | | High value | 60,100 | 29.1 | |
| | Chongqing | Low value | 856 | 0.6 | |
| | | Central value | 2,940 | 2.1 | |
| | | High value | 8,430 | 5.9 | |
| Calculation done by Beijing Academy of Environmental Sciences (1998) (money terms in 1995 CNY, numbers in brackets have been adjusted to 1998 CNY by price index) | Beijing | Human health | 680 (707) | 0.3 | Health damage caused by TSP and $SO_2$ |
| | | Other losses | 2,268 (2,359) | 1.2 | |
| | | Total | 2,948 (3,066) | 1.5 | |
| Calculation done by Chang and Hu (1996) (money terms in 1993 CNY, numbers in brackets have been adjusted to 1998 CNY by price index) | Chongqing | Human health losses | 524 (762) | 0.5 | No specific pollutants |
| | | Other losses | 1,241 (1,806) | 1.3 | |
| | | Total | 1,765 (2,568) | 1.8 | |

*Sources:* World Bank (1997); Ostro (1994, 1996); Rowe, Long, and Chesnut (1995); Beijing Academy of Environmental Sciences (1998); Chang (1996)

*Notes:* (1) For more details of the valuation process, please refer to Mao and Guo (2002). (2) COI = cost of illness; $PM_{10}$ = particulate matter less than 10 micrometer in diameter; $SO_2$ = sulfur dioxide; TSP = total suspended particles; WTP = willingness to pay

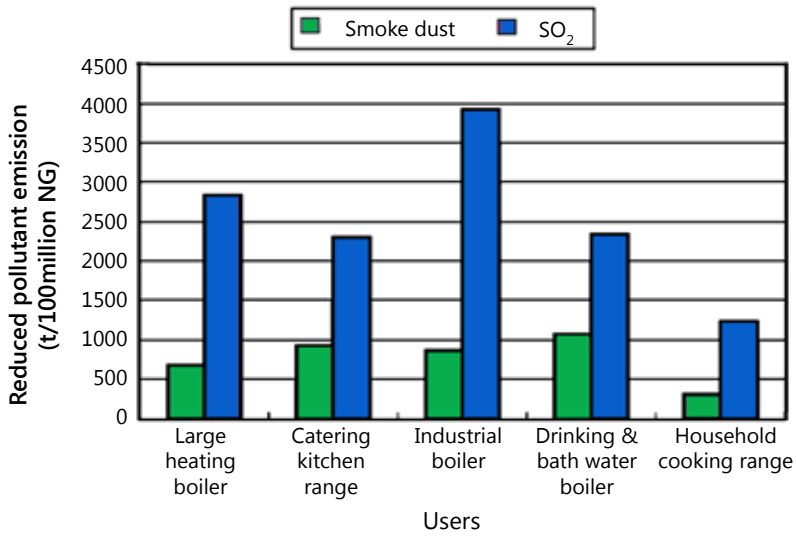


**Figure 1. Pollutant emissions reduction effect of substituting natural gas for coal**

## Natural Gas is a Clean Fuel

Natural gas is a high-quality energy source; it is very efficient and has a low pollutant content and emissions. When consumers substitute NG for coal, emissions of smoke-dusk, $SO_2$, NOx (nitrogen oxide) and CO (carbon monoxide) fall dramatically (Figure 1).

Given the low proportion of natural gas and the high proportion of coal within China's reserves of energy resources, there seems to be a significant potential to use NG as a fuel. However, this has proven to be controversial. The following sections will present the pros and cons of using NG as a substitute for coal.

## Why Hesitate to Use Natural Gas as a Substitute for Coal?

### *Natural gas is expensive and coal is cheap*

In order to examine the financial burden of using NG from the point of view of consumers, we calculated the increase in cost to consumers who substitute NG for coal. Three different costs were taken into account: fuel prices, equipment expenditure, and operational costs. NG substitution means higher fuel costs, as it is considerably more expensive than coal in terms of price per unit of thermal value, as shown in Table 2.

Substituting NG for coal also requires a large expenditure, as consumers need to either convert their coal boiler into an NG boiler, or replace the old piece of equipment with a new one. Except for household (residential) consumers, coal is much cheaper than gas, so most users will pay much more after switching to NG (Table 3).

**Table 2. Price of natural gas and coal in Beijing**

| Unit Fuel | Caloric Capacity | Price per kg or $m^3$ | Price per 1,000 kcal* |
|---|---|---|---|
| Shanxi coal | 6,200 kcal/kg | CNY 0.22 / kg | CNY 0.04 / 1,000 kcal |
| Shanganning natural gas | 8,480 kcal/$m^3$ | CNY 1.40 / $m^3$<br>CNY 1.80 / $m^3$ | CNY 0.17 / 1,000 kcal<br>CNY 0.212 / 1,000 kcal |

*Notes:* (1) * Converted to the same thermal unit. (2) kcal = kilocalorie

**Table 3. Annual incremental costs for different users in a 1-billion-$m^3$ natural gas project (in '000 CNY per year)**

| No. | Users | | Household Cooking Range | Catering Kitchen Range | Drinking and Bath Water Boiler | Industrial Boiler | Large Heating Boiler |
|---|---|---|---|---|---|---|---|
| 1 | Equipment fee (occurs in Year 1) | | 5,360 | 1,390 | 3,090 | 8,060 | 6,110 |
| 2 | Fuel cost | Coal fuel fee | 169,630 | 24,230 | 39,660 | 326,900 | 122,710 |
| | | Natural gas fee | 118,610 | 104,300 | 115,900 | 909,740 | 517,560 |
| | | Cost difference between natural gas and coal | –51,020 | 80,070 | 76,240 | 582,840 | 394,850 |
| 3 | Other saving of facility | | | | | 4,600 | 1,560 |
| 4 | Saving of land occupation | | | | | 3,540 | 1,340 |
| 5 | Saving of electricity | | | | | 8,670 | 2,610 |
| 6 | Saving to water fee | | | | | | 340 |
| 7 | Saving to labor force | | | | | | 1,100 |
| 8 | Saving of ash-slag removal | | 4,830 | 690 | 1,130 | 9,290 | 3,490 |
| 9 | Pollutant treatment reduction | | 5,600 | 1,730 | 2,300 | 27,440 | 10,200 |
| 10 | Annual cost (3)+(4)+(5)+(6)+(7)+(8)+(9)–(2) | | 61,440 | –74,870 | –66,630 | –529,990 | –368,940 |

*Notes:* (1) Item 1 occurs only in Year 1, so it is not included in the annual cost. (2) Negative sign means increased cost.

### *Urban household consumers cannot afford the installation fee*

Consumers in Chongqing and Beijing were respectively required to pay an initial installation fee (IIF) and a gas source fee (GSF) to local distribution companies before they could gain access to NG. In the case study, the GSF amounts to 70%–80% of total consumer costs in the first year of switching from coal to NG. For residential consumers who find it difficult to pay a one-off charge, the IIF/GSF sets a high-access threshold. For other potential consumers of commercial and small-scale industrial boilers, the fee makes the use of NG less attractive (Table 4). On the other hand, exemptions of GSF and IIF mean a loss for the NG company.

**Table 4. Gas source fee for different consumers in Beijing (1998)**

| Consumer Type | Households | Drinking and Bath Water Boilers and Public Kitchen Ranges | Industrial Boilers |
|---|---|---|---|
| Charging standard | CNY 2,300–2,400 per household | CNY 1,200/$m^3$ of daily gas consumption | CNY 704,000 per evaporation ton (or 0.7 megawatt). |

### *The high capital costs of the NG pipeline system are a headache*

In Chin, most of the NG fields lie on the west. This means that the NG must be transported through long-distance pipelines to reach the biggest potential markets, i.e. large cities in the east. But a lack of high-capacity, long-distance pipelines across China's vast land mass makes transportation difficult (Table 5). On the other hand, the lack of city terminal distribution systems hinders terminal consumption even when a high-pressure pipeline is present. Both long-distance pipelines and terminal distribution construction are capital intensive, and lack of capital is a big headache for both central and local governments.

**Table 5. Pipeline construction costs in China**

| Pipeline Item | Shanxi, Beijing | Jingbian, Xining | Luntai, Kuerle | Kuerle, Shanshan | Shanshan, Urumuchi |
|---|---|---|---|---|---|
| Pipe diameter (mm) | 660.00 | 426.00 | 457.00 | 610.00 | 457.00 |
| Length (km) | 860.00 | 489.00 | 195.00 | 476.00 | 308.00 |
| Total investment (billion CNY) | 39.35 | 7.89 | 3.29 | 18.30 | 5.23 |
| Unit investment ('000 CNY/km) | 4,575.60 | 1,631.90 | 1,687.20 | 3,844.5 | 1,698.10 |
| Investment per metric ton of pipeline ('000 CNY/t) | 31.40 | 25.30 | 25.20 | 32.30 | 25.30 |

*Source:* Yang (1998)
*Note:* Money terms are in 1998 CNY

### *NG resources are limited and their use is strictly controlled by the State*

Over 90% of NG production and allocation is controlled by the central government. The central government regulates the total NG supplied to enterprises, especially important users such as large chemical fertilizer factories and cities. Central planning often leads to a situation in which inefficient consumers with a large quota of NG are unable to use up their allocated quota, while other consumers faced with a shortage of NG are unable to buy more from the market. Producers are required to continue supplying gas to consumers who cannot pay, resulting in huge arrears.

Insufficient NG reserves probably necessitate strict controls for NG resources. According to Hu (2008), NG reserves in China are estimated at 47–52 trillion cubic meter ($m^3$), of which about 20 trillion $m^3$ are recoverable. With a huge population, the per capita average of NG resource amounted to only 4% of the world average level by the end of 2006.

## Reasons to Support NG Substitution

### *Research suggests that the highest priority is to use NG for residential fuel*

Energy saving was regarded as the first criteria by Jiang (1993) for the selection and use of NG, i.e., the allocation of resources according to energy efficiency. Energy consumption of NG and coal in three different applications are compared in Table 6. The conclusion was similar to Song's study: NG should be given the highest priority as a residential fuel (Song 1999) in view of the savings that would be made in terms of the consumption of coal (Table 7).

**Table 6. Energy consumption comparison of natural gas and coal**

| Application | Unit | Natural Gas | | Coal | | | Data Source |
|---|---|---|---|---|---|---|---|
| | | Volume ($m^3$) | Energy Consumption (kJ) | Volume (kg) | | Energy Consumption | |
| | | | | Raw Coal | Standard Coal | kJ | |
| Ammonia synthesizing | per kg | 1.053 | **40,994** | 1.880 | 1.343 | **39,307** | (1) |
| | relative value | 100 | **100** | 179 | 128 | **96** | |
| Power generation | per kWh | 0.18 | **7,007** | 0.43 | 0.31 | **8,990** | (2) |
| | relative value | 100 | **100** | 239 | 172 | **128** | |
| Civil fuel | relative value | 1.0 | **38,931** | 3.0 | 2.143 | **62,724** | (3) |
| | | 100 | **100** | 300 | 214 | **161** | |

*Sources:* (1) NBS (1991) (2) Huang (1993) (3) Chinese Society of Petroleum (1992)
*Notes:* (1) kg = kilograms; kJ = kilojoule; kWh = kilowatt-hour; $m^3$ = cubic meter (2) According to the Literature (1), the energy value of natural gas is 38,931 kJ/$m^3$, the raw coal unit energy value is 20,908 kJ/kg, and the conversion ratio of raw coal to standard coal is 0.7143 kJ/kg.

**Table 7. Coal saved by using 100 million $m^3$ of natural gas**

| Usage | | Coal Replaced (1,000 t) | Coal Saving (1,000 t) | Coal-Saving Ratio (%) |
|---|---|---|---|---|
| Civilian use (residential) | | 350 ~ 530 | 170 ~ 350 | 50 ~ 66 |
| Chemical industry raw material | | 280 ~ 320 | 100 ~ 140 | 36 ~ 44 |
| Industrial fuel | Middle- and small-sized boilers | 220 ~ 250 | 40 ~ 100 | 18 ~ 28 |
| | Other stove and furnace | 220 ~ 290 | 40 ~ 110 | 18 ~ 38 |
| | Puddling coke substitution | 280 | 100 | 36 |

*Source:* Song (1999)

### *There is no price advantage for NG as a raw material*

Over the past few decades, the government has subsidized NG as a raw material. Once this subsidy is removed, NG loses its price advantage over other raw materials. Wang (1998) examined the influence of raw material prices on the production costs of synthetic ammonia and urea. Residual oil and water coal slurry can be used in place of NG as raw materials in the production of synthetic ammonia and urea. Table 8 indicates that synthetic ammonia and urea production costs were more sensitive to NG prices than to other raw materials.

**Table 8. Effect of raw material prices on production costs of synthetic ammonia and urea**

| Material Price/ Production Cost | | Natural Gas (CNY/m³) | | | Residual Oil (CNY/t) | | | Water Coal Slurry (CNY/t) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.5 | 0.8 | 0.9 | 600 | 900 | 1000 | 100 | 200 | 300 |
| Synthetic ammonia | Production costs | 780 | 1,100 | 1,210 | 1,070 | 1,430 | 1,550 | 920 | 1,060 | 1,200 |
| | Cost elasticity | | 0.68 | 0.8 | | 0.67 | 0.76 | | 0.15 | 0.26 |
| Urea | Production costs | 710 | 900 | 960 | 880 | 1,090 | 1,160 | 790 | 870 | 950 |
| | Cost elasticity | | 0.45 | 0.53 | | 0.48 | 0.58 | | 0.10 | 0.18 |

*Source:* Wang (1998)

### *Clean coal cannot solve the problem of small-scale coal use*

Generally, clean coal technology is superior to NG substitution in terms of pollutant-emission reduction per unit of money spent. However, highly efficient scrubbing technologies, such as flue gas desulfurization and fluidized bed combustion, can only be used by large coal consumers, such as thermal power plants. Small and scattered coal users, such as households and small-scale boilers, contribute most of the low altitude $SO_2$ emissions in urban zones because they have a much lower dispersion rate than do large point sources with high chimneys. The pollutant reduction rates achieved by available clean coal technology on small and scattered emitters are far from satisfactory, while NG has an almost zero pollutant-emission rate. Therefore, substituting NG for coal used in households and small boilers would have a lower marginal pollutant reduction cost and higher environmental benefits (Appendix 1).

### *The CBA of urban NG substitution*

A more formal decision-making vehicle is cost-benefit analysis (CBA). In order to perform a CBA for using NG as a substitute for coal, NG substitution projects in Beijing and Chongqing were examined, and their NPV (net present value) and IRR (internal rate of return) were calculated under different scenarios. According to the CBA, in general, substituting NG for coal—especially nonpoint users—makes the most sense from a cost-benefit point of view in large cities, where there is a dense population and intense economic activity (Appendix 2).

### *New sources of NG guaranteed*

In the early 2000s, new large-scale NG fields were found in the Sh'anganning area.[3] Afterward, new NG supplies were sourced from Russia (Siberia), Central Asia, and Southeast Asia. Liquefied natural gas (LNG) importation from the Middle East could also be a diversified source of NG supply.

## Your Assignment

1. Would using NG as a substitute for coal be a feasible choice or not?
2. As a decision maker, what proof do you need to collect to support your decision?
3. What criteria would you choose to support your argument?
4. If we decide to say "yes" to NG substitution, how do we achieve this substitution?
5. What types of policies and strategies could you suggest using?
6. What are the necessary long- and short-term strategies?
7. What is the feasibility of the various policies, and what are their pros and cons?

The following section provides some preliminary policy proposals for discussion and debate.

## Policy Options

### *Command-and-control instruments*

Since the end of 1998, Beijing has issued several regulations related to pollution emissions in urban areas due to the deteriorating air quality. One of the most important has been to designate non-coal areas, in which all coal-burning facilities must switch to NG or another clean fuel. Although arbitrary, command-and-control instruments have been an effective and rapid way of helping to control serious air pollution problems.

### *Economic incentive instruments: Subsidizing the clean and taxing the dirty*

As a way of encouraging the use of NG in large cities as a residential and commercial fuel, there could be a system of economic penalties and incentives. The government could choose to subsidize municipal residents' NG use and surcharges on residential consumers (e.g., GSF and IIF) could also be cancelled. At the same time, the government could stop subsidizing NG for chemical fertilizer production.

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[3] *A triangle-shaped area in the region where Sh'anxi, Gansu, and Ningxia provinces meet*

In September 1999, the Beijing Environmental Protection Bureau (EPB) raised the pollution charge for $SO_2$ emissions caused by coal burning to CNY 0.50/kg for low sulfur content coal and CNY 1.20/kg for high sulfur content coal. However, even with these higher rates, the $SO_2$ emission charge amounts to only a small fraction of consumers' total fuel costs, and it does not reflect the environmental damage caused. Only when the charge is high enough will it become a useful tool for encouraging NG substitution.

### *More preferential quotas for civil use in the national plan*

Given China's limited NG resource endowment, as well as the natural monopoly inherent in the NG industry (especially in NG transportation), government regulations and plans are inevitable in the foreseeable future. However, government allocation preference should go to residential use.

### *Guaranteeing long-term NG supply*

Guaranteeing the long-term supply of NG requires both multiplied and stabilized long-term supply source contracts and huge investments in infrastructure, i.e., long-distance pipelines, storage, local branches, and facilities.

### *Launching market-oriented system reform in the NG industry*

The NG industry is strictly controlled by the central government and participation by private and foreign companies is prohibited. There has been a shortage of capital in all sectors of the industry for a long time. The level of exploration is insufficient to determine the true potential of NG reserves. The transportation system does not have enough funds to renew pipelines and pumping and gas-clearing equipment. The municipal NG allocation system has insufficient resources to expand its branch and sub-branch pipeline system. An injection of both foreign and private capital would be a good solution to these problems.

Since, in practice, the old planned system is one of the main barriers to NG penetration, it could be transformed into a more open and flexible system. For example, there could be more than one supplier in the NG market, and supply and transportation services could be separated so that consumers can choose the best well-head and transportation price combination.

Since the NG transportation system has a natural monopoly, it must be strictly regulated to prevent the provider from abusing its privilege. NG pricing also needs to be changed from a central-government method to a market-adjustment method.

## Summary: Epilogue without an Ending

In August 2007, NDRC published the NG Utilization Policy.[4] This policy, for the first time, prioritized civilian use of NG, encouraged it as a utilization option, and at the same time regulated against and limited the use of NG in the chemical industry. On 14 October, 2012, NDRC revised and republished the latest version of the NG Utilization Policy[5] in an attempt to encourage the rational development of NG in civilian use.

Throughout 2012–2014, North China suffered from serious attacks of haze and fog—the battle against air pollution has yet to be won, and the substitution of NG for coal is just the first skirmish in what will be a long war.

## Your Assignment

What have we learned about decision making? When faced with issues related to decision making, leaders are often confronted with the following questions:

1. What is the main problem that they should deal with?
2. What are the alternative policy options to deal with the problem?
3. What criteria should be used to evaluate the alternative policy options?
4. Whose interests should be considered and how will they be weighed in making the decision?
5. Can the policies/strategies suggested be implemented in the real world?
6. What conditions must be satisfied for the proposed solution to work?

Form yourself into groups and discuss the answers to the questions listed above. Write your answers and be ready to present them.

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## Appendix 1

### *Natural gas vs clean coal technology*

Clean coal technology is a general term for a range of technologies aimed at reducing the pollutant emissions of coal and improving its energy efficiency. The basic framework of China's clean coal technology includes processing (coal washing, coal briquettes, and coal slurry); burning (fluidized bed combustion process, powdered coal burning, and combined-cycle turbine); transforming (gasification and liquefaction); pollution control technology (flue gas desulfurization); and the comprehensive utilization of coal powder (Fan 1998).

Generally, clean coal technology is superior to natural gas substitution in terms of pollutant-emission reduction per unit of money spent. But this does not mean that natural gas substitution should be ignored as a way of reducing pollution. There are at least two reasons for this.

First, some highly efficient scrubbing technologies, such as flue gas desulfurization and fluidized bed combustion, can only be used by large coal consumers, such as thermal power plants. Small and scattered coal users, such as households and small-scale boilers, can only use a few clean coal technologies, such as coal briquettes and low sulfur coal substitution. These nonpoint sources contribute most to the low-altitude $SO_2$ emissions in urban zones because they have a much lower dispersion rate than those of large point sources with high chimneys (in Chongqing, for example, the contribution rate is 70%–80%). Also, the pollutant reduction rate achieved by available clean coal technology is far from satisfactory, while natural gas has an almost zero pollutant-emission rate (see Figure A1). Therefore, substituting natural gas for coal in households and small boilers would have a lower marginal pollutant reduction cost and higher environmental benefits than it would be for large-point polluters.

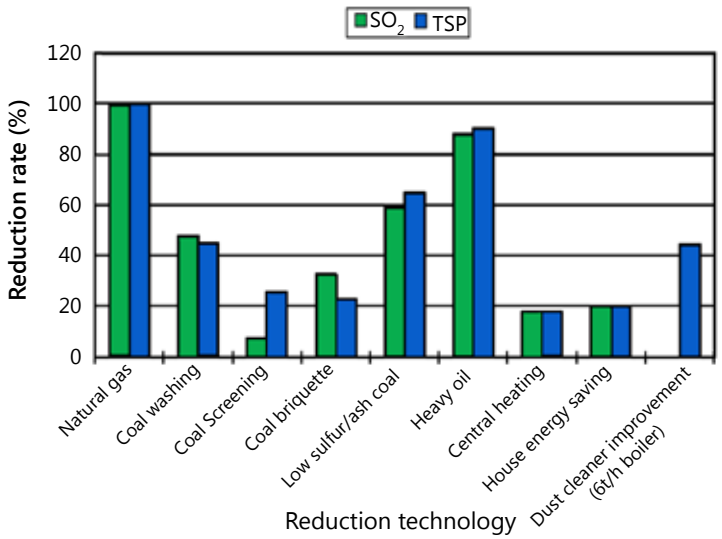


**Figure A1. Reduction rates of some pollution reduction measures**

*Source:* Beijing Academy of Environmental Sciences (1998)

Second, the administrative and monitoring costs associated with implementing clean coal technology are high. Furthermore, it is impossible to monitor all small coal consumers. If the use of coal is permitted, the probability of coal users using cheaper "dirty coal" instead of expensive "clean coal" is high.

## Appendix 2

### *Cost-benefit analysis of urban natural gas substitution: Beijing and Chongqing*

In order to perform a cost-benefit analysis of using natural gas as a substitute for coal, we examined the natural gas substitution projects in Beijing and Chongqing and calculated their NPV and IRR under different scenarios.

***Chongqing natural gas project.*** The Chongqing project is an important municipal ambient air environmental protection project sponsored jointly by China's State Environmental Protection Administration (SEPA) and the Japanese Government, with the support of a soft loan from Japan. The project consists of substituting natural gas for coal in 1,153 boilers with a water evaporation capacity of under 10 metric tons (t) per hour; 18,500 catering cooking ranges; and 1,500 drinking water boilers (Chongqing Gas Corporation Ltd. 1998). The estimated pollution reduction is shown in Table A1.

In the project, dose-reaction function models and the benefit-transfer method are used to estimate the monetary benefits derived from the reduction in air pollution (Mao and Guo 2002). The results are shown in Table A2. Pipeline system costs for the project are shown in Table A3, while the results of the cost-benefit analysis are shown in Table A4.

Even based on the low value, the Chongqing natural gas project has satisfactory NPV and IRR values.

### *Beijing natural gas project*

Tables A5–A9 show the results for a 1-billion-$m^3$ natural gas substitution project in Beijing. Unlike Chongqing, which has its own gas field, Beijing has to import natural gas from Shaanxi province. The construction cost of the Shaanxi-Beijing long-distance natural gas transportation line is estimated to be CNY 3.935 billion. Of this, fixed capital costs amounted to CNY 3.509 billion (see Table A8 for a cost breakdown).

The urban allocation pipeline system costs are also high. The Beijing Natural Gas Corporation controls up to 1,200 km of urban natural gas distribution pipelines. Its total fixed assets amount to CNY 0.8 billion (Beijing Academy of Environmental Sciences 1998). It is assumed here that the entire amount consists of the urban allocation system construction expenditure.

Operation and Management (O&M) costs are assumed to be 30% of the gateway price of natural gas (Beijing Academy of Environmental Sciences 1998). In the 1-billion-$m^3$ substitution scenario, this works out to CNY 297 million per year.

**Table A1. Air pollutant reduction effect of the Chongqing natural gas substitution project**

| Pollutant | National Air Quality 2nd Class Standard ($mg/m^3$) | WHO Standard ($mg/m^3$) | Concentration before the Project* ($mg/m^3$) | Pollution Concentration Reduction ($mg/m^3$) | Reduction Rate (%) | Pollution Concentration after the Project ($mg/m^3$) |
|---|---|---|---|---|---|---|
| $SO_2$ | 0.060 | 0.050 | 0.183 | 0.149 | 81.4 | 0.034 |
| TSP | 0.200 | | 0.234 | 0.082 | 35.0 | 0.152 |
| $PM_{10}$** | | 0.070 | 0.140 | 0.049 | 35.0 | 0.091 |

*Notes:* (1) *1998 Pollution concentration in Chongqing urban area. (2) ** Conversion coefficient between $PM_{10}$ and TSP used here is 0.6. (3) $mg/m^3$ = milligrams per cubic meter; WHO = World Health Organization

**Table A2. Estimated monetary benefit of environmental quality improvement from the Chongqing natural gas project (billion CNY)**

| Benefit | Low Value | Central Value | High Value |
|---|---|---|---|
| Monetary benefit of $SO_2$ reduction | 0.618 | 2.87 | 13.10 |
| Monetary benefit of $PM_{10}$ reduction | 0.600 | 2.06 | 5.92 |
| Total benefit | 1.220 | 4.93 | 19.00 |

*Note:* Money terms in CNY 1998 rate

**Table A3. Pipeline system costs within the Chongqing natural gas project (in '000 CNY)**

| Items / Year | Fixed Capital Investment | Circulating Fund | Operation Cost (including NG purchase cost of NG corporation) | Cash Outflow |
|---|---|---|---|---|
| 1 | 58,966.6 | | | 58,966.6 |
| 2 | 239,910.4 | 4,612.7 | 152,820.3 | 397,343.4 |
| 3 | 327,703.1 | 6,025.5 | 350,154.9 | 683,883.5 |
| 4 | 42,455.1 | 5,939.5 | 545,926.3 | 594,320.9 |
| 5 | 33,638.9 | 6,003.1 | 724,545.4 | 764,187.4 |
| 6 | | 6,002.3 | 724,545.4 | 730,547.7 |
| 7 | | 6,003.1 | 724,545.4 | 730,548.5 |
| 8–20 | | | 724,545.4 | 724,545.4 |

*Note:* Money terms in CNY 1998 rate.

**Table A4. Cost-benefit analysis of the Chongqing natural gas project (in '000 CNY)**

| Scenario / Indicators | Low Value | Central Value | High Value |
|---|---|---|---|
| NPV (Net Present Value) | 2,225,541.6 | 18,649,523.3 | 81,009,089.8 |
| IRR (Internal Rate of Return) | 26.38% | 74.68% | 143.03% |

*Notes:* (1) Money terms in CNY 1998 rate. (2) Assumptions: discount rate = 12%, discount period = 20 years

**Table A5. Pollutant emission reduction from 1-billion-m³ natural gas substitution in Beijing**

| Burning Facility | Natural Gas Allocation (1 billion m³ per year) | Coal Replaced (1,000 t per year) | Reduced Emissions (1,000 t per year) | |
|---|---|---|---|---|
| | | | $SO_2$ | TSP |
| Household cooking ranges | 0.85 | 520.2 | 1.05 | 0.27 |
| Catering cooking ranges | 0.58 | 198.7 | 1.34 | 0.96 |
| Drinking/bath water boilers | 0.64 | 179.6 | 1.51 | 0.69 |
| Industrial boilers | 5.05 | 1,425.3 | 19.78 | 4.39 |
| Large heating boilers | 2.88 | 557.8 | 8.13 | 1.95 |
| Total | 10.00 | 2,881.6 | 31.80 | 8.30 |

*Source:* Beijing Academy of Environmental Sciences (1998)

**Table A6. Pollutant concentration reduction from 1-billion-m³ natural gas substitution in Beijing**

| Items/Period | Coal Substitution (1,000 t) | Concentration before the Project (mg/m³) | | | Pollution Concentration Reduction (mg/m³) and Reduction Rate | | | Pollution Concentration after the Project (mg/m³) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $SO_2$ | TSP | $PM_{10}$ | $SO_2$ | TSP | $PM_{10}$ | $SO_2$ | TSP | $PM_{10}$ |
| Heating season | 1,634.8 | 0.252 | 0.431 | 0.259 | 0.021 (8.4%) | 0.017 (3.9%) | 0.010 (3.9%) | 0.231 | 0.414 | 0.248 |
| Non-heating season | 1,246.8 | 0.042 | 0.348 | 0.209 | 0.012 (28.6%) | 0.013 (3.7%) | 0.008 (3.7%) | 0.03 | 0.335 | 0.201 |

**Table A7. Monetary benefit from 1-billion-m³ natural gas substitution in Beijing (billion CNY)**

| Indicator | Low Value | Central Value | High Value |
|---|---|---|---|
| Monetary benefit of $SO_2$ reduction | 0.340 | 1.20 | 3.30 |
| Monetary benefit of $PM_{10}$ reduction | 0.204 | 0.95 | 4.33 |
| Total benefit | 0.544 | 2.15 | 7.63 |

*Note:* Money terms in CNY 1998 rate.

**Table A8. Breakdown of fixed capital costs of the Shan-Jing natural gas pipeline project (in '000 CNY)**

| Items | Equipment Purchase | Architecture Engineer | Equipment Engineer | Other | Total Investment | Proportion of Total Investment (%) | Proportion of Engineer Cost (%) |
|---|---|---|---|---|---|---|---|
| Engineer cost | 302,220 | 521,470 | 1,723,340 | 14,930 | 2,561,960 | 73.01 | 100 |
| Pipe material | | | | | 933,690 | 26.61 | 36.44 |
| Pipeline equipment engineer | | | | | 994,040 | 28.33 | 38.80 |
| Station-field engineer | | | | | 249,700 | 7.12 | 9.75 |
| Large penetration and bridge engineer | | | | | 54,430 | 1.55 | 2.12 |
| Communication engineer | | | | | 83,880 | 2.39 | 3.27 |
| Automatic control engineer | | | | | 25,000 | 0.71 | 0.98 |
| Dispatching center engineer | | | | | 171,570 | 4.89 | 6.70 |
| Base engineer | | | | | 49,650 | 1.41 | 1.94 |
| Other cost | | | | 59,7,490 | 597,490 | 17.03 | 23.32 |
| Preparation budget | | | | 34,9,600 | 349,600 | 9.96 | 13.65 |
| Total fixed capital | 302,220 | 521,470 | 1,723,340 | 96,2,020 | 3,509,050 | 100 | 136.97 |
| Ratio (%) | 8.61 | 14.86 | 49.11 | 27.42 | 100 | | |

*Source:* Yang (1998)
*Note:* Money terms in CNY 1998 rate.

Table A9 shows that the IRR and NPV are unsatisfactory when the estimated environmental benefit is low. Two factors can explain this. The first is due to the large investment in pipeline construction; in the 1-billion-$m^3$ scenario, economies of scale have not been achieved. As the quantity of natural gas transported increases, NPV and IRR also tend to increase. Second, the allocation of natural gas has not been optimized, which means that the assumed allocation scenario does not conform to the marginal cost minimization rule.

Generally, substituting natural gas for coal—especially nonpoint users—makes the most sense from a cost-benefit point of view in large cities, where there is dense population and intensive economic activity.

**Table A9. Cost-benefit analysis for the Beijing natural gas project (in '000 CNY)**

| Benefit Estimated Indicators | | Low Value | Central Value | High Value |
|---|---|---|---|---|
| 1-billion-$m^3$ scenario | NPV | –2,405,669.5 | 6,876,035.1 | 38,547,106.5 |
| | IRR | 3.0% | 29.4% | 80.6% |
| 3-billion-$m^3$ scenario | NPV | –547,365.5 | 27,297,748.1 | 122,310,962.5 |
| | IRR | 10.9% | 49.7% | 126.3% |

*Notes:* (1) Money terms are in CNY 1998 rate. (2) Assumptions: discount rate = 12%, discount period = 20 years

Indonesian motorists (fuel and diesel consumers) stuck in traffic. Photo by Budi Nusyirwan under creative commons license at www.flickr.com/photos/bukrie/14561469378

# Dilemmas of the Indonesian Fuel Subsidy: A Teaching Case Study

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Based on EEPSEA Research Report No. 2008-RR1: *The distributional impact of environmental policy: The case of carbon tax and energy pricing reform in Indonesia* by Arief Anshory Yusuf

*The objective of this case study is to introduce students to the issue of the distributional implications of environmentally motivated policies.*

*From the political economy perspective, there are always winners and losers from policy implementation. Understanding the distributional impact of environmental policy is important in two ways. First, after carefully designing a policy, its distributional implications must be considered so that its chances of successful implementation can be increased. Second, the policy must avoid conflict with other development agendas, such as the alleviation of poverty or the reduction of inequality.*

*The target audience of this case study is government officials, students of public policy, and economists, particularly development economists.*

## Introduction

In 2005, Indonesian President Susilo Bambang Yudhoyono (SBY) faced one of the biggest political risks ever. The world oil price increased to almost USD 50 per barrel, a 43% increase from the previous year; many analysts predicted that the trend would continue into the years ahead. If this situation had occurred in the 1970s, then it would have provided a windfall to the Indonesian economy because, at that point, Indonesia exported a lot of oil abroad. By 2005, Indonesia had become a net oil importing country; what made the situation critical was that consumption of fuel in the country was heavily subsidized. Early that year, the budget, which had assumed a much lower oil price, had been approved by parliament. An unexpectedly large increase in the world oil price would force additional government spending and, if the increase was significant enough, it could endanger the overall budget structure as well as other government programs. In a worst-case scenario, the government could shut down.

Vehicle fuel subsidy is not unique to Indonesia. In 2012, as much as USD 110 billion was spent on gasoline and diesel subsidies all over the world, creating USD 44 billion of annual deadweight loss. In Southeast Asian countries such as Malaysia, Brunei, and Thailand, a lot of taxpayers' money has been spent on subsidizing fuel (Figure 1).

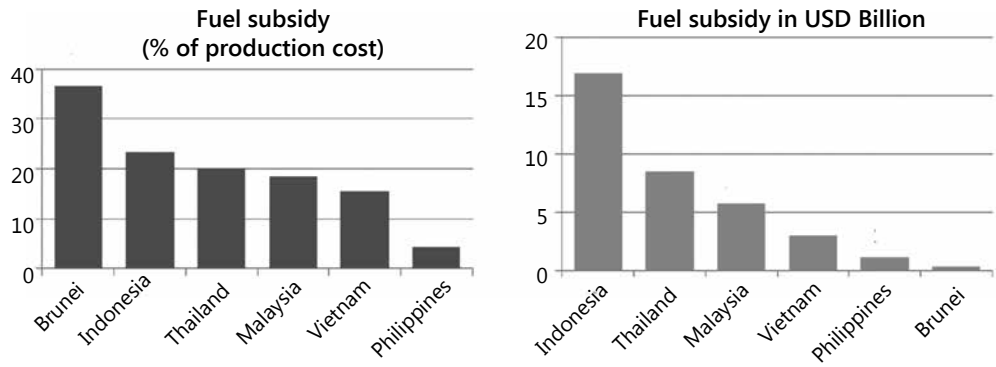


**Figure 1. Fuel subsidy in Southeast Asian countries, 2011**
*Source:* IEA (2012)

In countries where fuel is subsidized, the price of fuel is administered and decided by the government. Reducing fuel subsidy involves increasing the price of fuel, which no one likes. *France 24* (3 January, 2012) reported that following the announcement of the end of fuel subsidies in Nigeria in 2012, protesters had shut petrol stations, formed human barriers along motorways and hijacked buses in Lagos, the country's biggest city, in anger at the shock doubling of fuel prices. It was also reported that one demonstrator had been shot dead in the west of the country. In 2013, the *FirstPost* (26 September, 2013) reported that at least 24 people had been killed in Sudan in clashes sparked by cuts in fuel subsidies. Meanwhile, *The Wallstreet Journal* (3 January, 2011) reported that following large-scale protests against fuel subsidy reductions in Bolivia in 2011, the government had been forced to reinstate the subsidy amid fears of an escalating political crisis.

## Problems with Fuel Subsidies

Reducing or even eliminating fuel subsidies has been recommended by many economists for many years. Fuel subsidies create market distortion by disregarding the economic value of the fuel, creating excessive consumption and discouraging energy substitution.

Fuel subsidies are also regarded as a major cause of environmental problems. A study published in 2010 by a consortium of international organizations projected that phasing out fuel subsidies by 2020 would reduce primary energy demand at the global level of 5.8%, and a fall in energy-related carbon dioxide emissions of 6.9%, compared with a baseline in which subsidy rates remain unchanged (IEA et al. 2011). Other than global pollution, such carbon dioxide emissions, contribute to climate change; excessive fuel consumption also creates local pollution and traffic problems. Fuel subsidies also discourage the development of more traffic-free public transport infrastructure, which is already a major public concern in large Indonesian cities.

However, in the Indonesian context, the biggest concern is the fiscal burden of the subsidy. In a country where there are other much more pressing issues such as poverty, education,

and health, allocating such a large share of public spending to fuel subsidy seems to be inconsistent with rational resource allocation principles. However, historical data suggests that the general price index will always increase following an increase in fuel subsidy (Figure 2). Many studies suggest that a large price increase normally lasts for three months; the price stabilizes thereafter.

## Subsidized Fuel in Indonesia

In the case of Indonesia in 2005, there are different kinds of subsidized fuel. Fuel used for vehicles (gasoline and diesel) and fuel used for domestic cooking (kerosene). Most of the subsidy goes to kerosene, and its domestic price is the lowest of all the fuels, which is 85% below the cost of production or its price on the international market (Table 1). This is the source of the increasing burden on the budget. Most consumers of kerosene are low-income households in both urban and rural areas, and spending on kerosene is an important part of their expenditure.

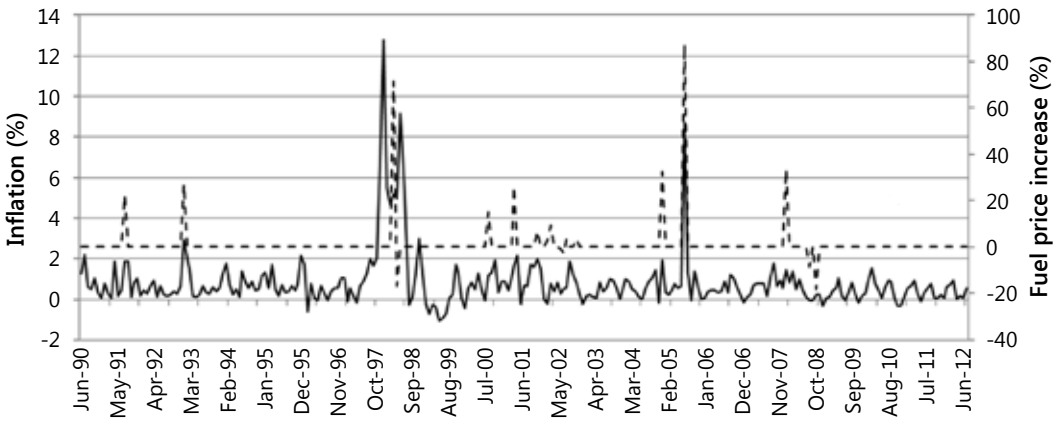


**Figure 2. Monthly fuel price increases and inflation in Indonesia**

**Table 1. Fuel subsidy and share of expenditure in households in Indonesia (2005)**

| | Gasoline | Diesel | Kerosene | Public Road Transportation |
|---|---|---|---|---|
| Subsidy (trillion IDR/$10^{12}$) | 12.5 | 24.2 | 37.9 | |
| Initial price (IDR/l) | 2,400 | 2,100 | 700 | |
| Subsidy (% of cost/market price) | 50% | 60% | 85% | |
| **Household Expenditure Share** | | | | |
| Urban | | | | |
| Lowest 40% income | 1.0% | 0.1% | 3.2% | 3.0% |
| 40% middle class | 1.8% | 0.3% | 1.7% | 3.8% |
| Top 20% income | 2.3% | 0.9% | 0.4% | 2.9% |

*Table 1 continued*

| | Gasoline | Diesel | Kerosene | Public Road Transportation |
|---|---|---|---|---|
| Rural | | | | |
| Lowest 40% income | 0.4% | 0.0% | 2.5% | 1.6% |
| 40% middle class | 1.0% | 0.2% | 2.4% | 2.0% |
| Top 20% income | 1.7% | 0.8% | 1.6% | 1.9% |

*Source:* Yusuf (2006)

The second-biggest subsidy goes to diesel. Its price is kept 60% below market price. Diesel is used in trucking, shipping, and public transport. These vehicles are essential for the delivery of goods. An increase in the price of diesel would have a large impact on inflation.

The last subsidy goes to gasoline. Its price is kept 50% below the cost of production. The biggest users of this fuel are the urban rich and the urban middle class. This fuel is not only used in private cars but also in motor vehicles. The urban rich and urban middle class are population groups with significant political influence.

Another complication is the second-round effect that can happen if the price of fuel increases. The biggest second-round impact would be the impact on the price of public transportation. Public transport would be the first business to pass any increase in the price of fuel on to their customers.

## SBY's Problem

By the middle of 2005, the Indonesian president (SBY) was faced with three distinct problems.

1. The government cannot afford to keep subsidizing domestic fuel consumption in light of the increasing world oil price (USD 50 per barrel instead of USD 24 a barrel).
2. The increasing fuel price (or reducing fuel subsidy) makes the poverty reduction target for 2005 more difficult to achieve because inflation may reduce the purchasing power of the poor.
3. Last, but not least, SBY may experience a loss in popularity and so risks not being reelected as President—it is also possible that his political rivals in parliament will take advantage of the situation and attempt to oust him. SBY's political party is not dominant in parliament. SBY did not promise that fuel would not increase in price during his term as president, but imposing a reduction in the fuel subsidy would be a very big political risk.

After consulting his advisors, SBY has several policy options as follows:

***Option 0:*** Do nothing and the deficit will balloon

***Option A:*** Non-price measures

Non-price measures are policies that do not involve an increase in fuel prices but instead attempt to limit the quantity of fuel consumption.

1. Create a massive media campaign to educate the public about the importance of reducing fuel consumption.
2. Establish a rationing system in which private car owners can only buy a certain quantity of fuel each month.
3. Set up a zoning system where subsidized fuel is sold only outside Jakarta, the nation's capital, and the region of biggest fuel consumption.

***Option B:*** Price measures

Price measures are policies that involve increases in the price of fuel. This can be combined with additional measures to compensate households. This kind of policy package has the following key elements:

1. Stop selling subsidized fuel to private cars but still sell it to cars used for public transportation and motorcycles.
2. Increase the price of all fuel commodities (thereby reducing the subsidy). The amount of increase can differ between fuel types. As mentioned previously, there are three kinds of subsidized fuel, namely, (a) gasoline, which is normally used in private cars and motorcycles; (b) diesel oil, mostly used in trucks, buses, and some private vehicles; and (c) kerosene, which is normally used as fuel for cooking.
3. Provide nonconditional cash transfers to households.

SBY is given four options for a cash compensation scheme. Based on the Minister of Finance's assessment, the budget available for compensation is around IDR 14–16 trillion.

1. ***Scheme A.*** Cash transfers are given to all poor households (poor = a household that spends below the national poverty line). The value of the transfer is IDR 150,000 per month per household, given for one year (12 months). The monthly transfer is the same for all targeted households.
2. ***Scheme B.*** Cash transfers are given to all poor households and all near poor households (households whose expenditure is below 1.2 times the national poverty line). The value of the transfers is smaller, i.e., IDR 70,000 per month per household, but the number of target households is much larger.

3. ***Scheme C.*** Cash transfers are given to all poor households (not including the near poor) but urban households are given a larger allowance than rural households. The reason is that urban poor households will feel the effects of a reduction in fuel subsidy to a far greater extent than rural households will. Urban poor households would be given IDR 200,000 a month, whereas rural poor households would be given IDR 100,000 a month.
4. ***Scheme D.*** Cash transfers are given to all poor and near poor households. The poor and the near poor in urban areas are given IDR 100,000 a month and those in rural areas are given IDR 50,000 a month.

Table 2 summarizes the four options of the compensation scheme.

**Table 2. Alternative compensation scheme and its budget implications**

| Cash Compensation Scheme | Urban Areas | Rural Areas | All Areas |
|---|---|---|---|
| Number of poor households (millions) | 3.1 | 5.7 | 8.8 |
| Number of poor + near poor households (millions) | 6.7 | 12.3 | 19.1 |
| **Scheme A (Target: The Poor)** | | | |
| Allowance (per month per household, IDR) | 150,000 | 150,000 | |
| Total annual budget needed (trillion IDR/1012) | 5.6 | 10.2 | 15.8 |
| **Scheme B (Target: The Poor)** | | | |
| Allowance (per month per household, IDR) | 70,000 | 70,000 | |
| Total annual budget needed (trillion IDR/1012) | 5.7 | 10.3 | 16.0 |
| **Scheme C (Target: The Poor + Near Poor)** | | | |
| Allowance (per month per household, IDR) | 200,000 | 100,000 | |
| Total annual budget needed (trillion IDR/1012) | 7.4 | 6.8 | 14.2 |
| **Scheme D (Target: The Poor + Near Poor)** | | | |
| Allowance (per month per household, IDR) | 100,000 | 50,000 | |
| Total annual budget needed (trillion IDR/1012) | 8.1 | 7.4 | 15.5 |

*Note:* Poor = a household that spends below the national poverty line; Near Poor = households whose expenditure is below 1.2 times the national poverty line

## Your Assignment

SBY assigns three ministers—the Minister of Finance, Minister of Energy, and Minister of Planning—to put together a team to consider all of the above options and to recommend to him the best measure to be implemented. A series of consultation sessions with various groups are held. You will represent each of the following interest groups:

- the Government (which is represented by the Minister of Finance);
- a member of parliament representing the opposition party;
- a consortium of the urban poor, a nongovernmental organization;
- the National Association of Farmers; and
- an independent economist from a well-known university.

The consultation aims to resolve the following issues:

1. If fuel prices are increased, what level of increase could be implemented for all three types of fuel (i.e., gasoline, diesel, kerosene) that can save the government at least IDR 14 trillion, while also minimizing political resistance (and hence political crisis) and without undermining the poverty reduction target?
2. If a compensation policy is necessary, how can this be done? How should the target groups be chosen? What form should the compensation take? How large should the compensation be? Should the compensation be uniformly applied to all households or should it be applied differently in urban and rural areas? Consideration should be given to the mechanism of distribution of the compensation, the issue of leakages, mistargeting, and corruption.
3. Out of the four alternative non-price measures, which is the most effective measure that can potentially ease the governmental burden of fuel subsidy?

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