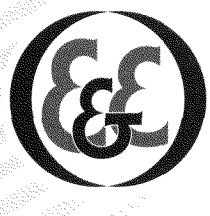
RESEARCH REPORT

NO. 2002-RR4

Economy and Environment: Case Studies in Cambodia

This report summarizes the results of four research projects that apply economic analysis to Cambodia's environmental problems. They assess the importance of income from forest products; impacts of agricultural chemical use; impacts from the proliferation of the *Mimosa pigra* weed; and conversion of flooded forests for rice production. The projects were carried out by teams of Cambodian researchers from government and non-government organizations.



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Economy and Environment: Case Studies in Cambodia

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Bruce McKenney, Editor

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EEPSEA was established in May 1993, to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach, involving courses, meetings, technical support, access to literature and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, Papua New Guinea and Sri Lanka.

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Foreword

Approximately 85 percent of Cambodians live in rural areas. They depend on natural resources - water, forests, soil and land — for their livelihoods. Rice and fish are the main staple diet of the Cambodians. Forests provide rural people with construction materials, firewood for cooking, and other products like bamboo and resin. Over the past decade, Cambodia's natural resources have been exploited in an unsustainable manner for a variety of reasons. This includes uncontrolled and illegal logging, over-fishing and illegal fishing practices, and weak natural resource policies, institutional capacity, and management.

The Royal Government of Cambodia recognizes the need for effective natural resource management, as indicated by the preparation of its first National Environmental Action Plan in 1998. This plan seeks to integrate natural resource and environmental concerns into economic development activities to support sustainable development. More recently, legislation has been drafted on land, forest, and fisheries management to ensure that present and future generations enjoy the social, economic, and environmental benefits of these resources.

In order to enhance Cambodia's capacity to develop appropriate natural resource policies for sustainable development, the Economy and Environment Program for Southeast Asia (EEPSEA) sponsored a one-month training course for 25 Cambodian nationals on microeconomics and cost-benefit analysis of environmental problems. The course was held in February-March 2000 and course participants included representatives from the Ministry of Environment, Ministry of Agriculture, Forestry, and Fisheries, Ministry of Economy and Finance, and non-governmental organizations. The focus was on environmental and economic development issues.

During the final week of the training course, EEPSEA invited participants to form teams and develop research proposals in environmental areas of their interest. Approved projects were then supported by EEPSEA and carried out by the research teams from April 2000 to October 2001. Technical support was provided by Bruce McKenney. The projects focused on some of Cambodia's most critical environmental issues, including the importance of income from forest products, impacts of agricultural chemical use, impacts from the proliferation of the *Mimosa pigra* weed, and conversion of flooded forests for rice production.

Many of the environmental issues selected for research by the EEPSEA teams have received little previous attention or study in Cambodia. This publication provides a summary of each research project's findings and recommendations. It is hoped that these summaries will show how economic analysis can be applied in the study of environmental problems and contribute in a meaningful manner to the debate surrounding natural resource management in Cambodia. For readers interested in obtaining the project's main report, please contact the research project's team leader (see information on research teams included in this publication).

David Glover, Director EEPSEA

FOREST USE AND PRODUCT FLOW IN CHUMKIRI DISTRICT, KAMPOT PROVINCE, CAMBODIA

Sy Ramony, Hou Kalyan, Chay Chetha, and Meas Sothunvathanak

1.0 INTRODUCTION

In Cambodia's predominantly rural economy, farmers represent about 85% of the workforce. In addition to agricultural activities, many of these farmers collect products from nearby forests to supplement their income. The forest has traditionally been viewed as a source of timber resources, but rural people also collect fuel wood and non-wood products such as rattan and bamboo, resins, honey, medicinal plants, and bush meats. The forests also provide a range of important non-extractive benefits to the rural people which include cultural values (e.g., spirit forests) and ecological services (e.g., watershed and flood control).

While it is widely accepted that many rural people derive benefit from the forests, there have been few, if any, attempts to quantify these benefits in terms of forest-dependent income. A better understanding of the extent to which the rural people depend on forest products to sustain their livelihood income could serve as a useful input to policy decisions on rural development and forestry management. In particular, it is hoped that where village income is highly dependent on forest products, policy interventions supporting increased community participation in forestry management are given strong consideration.

1.1 Study Objectives

The main objective of this study is to estimate the extent to which four rural villages in Chumkiri District, Kampot Province, depend on forest products to support their livelihood incomes. This level of dependence is considered an important criterion for evaluating potential community forestry development. Specifically, this study seeks to:

- Estimate the household net income from timber and non-timber forest resources as a proportion of total household net income;
- Assess the relative income values of different forest products;
- Document the non-extractive forest values (e.g., spirit forests);
- Identify problems related to forest use and product flow; and
- Identify the opportunities/constraints for developing community forests in the study areas.

2.0 RESEARCH METHODS

Four villages in Chumkiri District, Kampot Province were selected for this study — Mononop, Cheiteal, Chress, and Thmir. The criteria for selecting these villages included accessibility, security, and the relative proximity of the villages to forest areas. The study purposely selected two villages in close proximity to the forest and two villages several kilometers from the forest to allow for an assessment of how "distance from the forest" affects the forest dependent income. Primary data for this study was collected through participatory rural appraisal techniques, key informant interviews, and a household survey conducted over several trips to Chumkiri District during 2000-2001. Of the 1165 households in the four villages, 192 households were surveyed (about 16 %). All households interviewed for the survey were randomly selected.

3.0 FOREST MANAGEMENT

No clear forest management system exists for the forests used by the four villages in the study area. Over time, nearby forests have degraded requiring people to travel longer distances to collect forest products. For example, survey respondents noted that not long ago they could collect timber for building a house in a few days, but now they must spend 15-30 days traveling long distances to find suitable timber for house construction. Wildlife has also become scarce in nearby forests.

4.0 NET INCOME FROM FOREST DEPENDENT ACTIVITIES

Survey findings are divided into forest dependent livelihood activities (i.e., timber collection and non-timber forest products) and other income sources (i.e., rice, vegetable crops, livestock raising, and labor/business). Nearly 95 % of the households surveyed engaged in the collection of timber and/or non-timber forest products in 1999-2000. As shown in Table 1, the average net income from these activities accounted for a significant proportion (38 %) of the total net income for the four villages.[1] Although Chress and Thmir are located far from the forest, many people from these villages travel to the forest to collect bamboo and rattan to support local handicraft businesses. Given the importance of income from forest products, it is clear that the increasing forest resource scarcity and degradation could severely affect livelihood income in the four villages.

[1] Net income is estimated by subtracting costs of inputs from total income revenue. For example, for rice production, the cost of seeds, fertilizers, pesticides, and labor is subtracted from the rice yield revenues. *Average* net income is calculated by dividing the total income from an activity by *all* households surveyed (including those households that do not engage in the activity).

Table 1. Estimated Net Income from Forest Products Compared to Total Net Income

Livelihood Activities	*Mononop& Cheiteal (close to forest) Average annual income per HH*		*Chress & Thmir (far from forest) Average annual income per HH*		*All Four Villages Average annual income per HH*	
	(USD)	*%*	*(USD)*	*%*	*(USD)*	*%*
Timber*	112.55	29.6	92.85	27.7	102.90	28.7
NTFP	7.17	1.9	62.76	18.7	34.38	9.6
Forest Products Subtotal	**119.72**	**31.5**	**155.61**	**46.4**	**137.28**	**38.3**
Rice	118.78	31.3	72.91	21.7	96.32	26.9
Vegetables	5.96	1.6	10.03	3.0	7.95	2.2
Livestock	111.34	29.3	75.13	22.4	93.61	26.1
Labor/Business	23.92	6.3	21.76	6.5	22.87	6.4
Other Products Subtotal	**260.00**	**68.5**	**179.83**	**53.6**	**220.75**	**61.6**
Total HH Income	**379.72**	**100.0**	**335.44**	**100.0**	**358.03**	**100.0**

* Checkpoint expenses have been subtracted from total income.

Note: HH = Household
NTFP = Non-timber forest products

4.1 Checkpoint and Health Expenses

To remove forest products from the forest, villagers must pay checkpoint fees to the military police. These unofficial fees are not legal taxes; the military police pockets the money and provides no forest management services. On an average, villagers lose about 11% of their forest product income to checkpoint fees (USD 17.55 out of the annual forest product income of USD 154.83). This is a 5% loss of annual income. Clearly, checkpoint fees represent a significant burden on the villagers' forest product earnings.

In addition to checkpoint fees, survey respondents noted the high risk of illness, mainly from malaria, associated with long trips to the forest. On average, the villagers lose about 12% of their forest product income in lost workdays and medical expenses associated with treating illnesses contracted during trips to the forest. This is a loss in annual income of about 5%. It should be noted that these monetary estimates do not account for the pain and suffering experienced by villagers with illnesses.

4.2 Non-Extractive Forest Benefits

In addition to income benefits, the forests in the study area provide a number of non-extractive benefits. Villagers have identified several forest areas that are used as burial grounds. These forests are spiritually important; villagers pray before entering them. In

addition to the spiritual values, forest areas near Molech dam support recreation. Villagers also recognize the benefits of forests watershed in their area.

4.3 Relative Net Income from Forest Products Per Workday

Information on the relative net income from forest products can help to explain why the villagers have greater/lesser incentives for collecting different forest products. For example, in terms of potential income benefits, do the villagers have more incentive to collect timber or fuel wood? Although timber will bring a higher price at the market, it is also more expensive to collect due to the many workdays involved and high checkpoint costs. Fuel wood can be collected in far less time than timber, but the market price is much lower. By comparing the net income earned from collecting different forest products per workday, it is possible to gain a better understanding of the economic incentives for forest product collection.

As shown in Table 2, despite the high costs of collecting timber, it provides the highest income benefit (USD 3.20 per day). However, timber income per day does not include the possible expenses incurred due to illnesses contracted during timber collection. Collecting other forest products appears to provide almost as much income per day as timber but with less risk to health.

Table 2. Estimated Income per Day for Different Forest Products.

Forest Products	*Average Net Income Per Household Per Workday: All Four Villages*		
	% of HH collecting the forest product (%)	*Average number of days per year collecting the forest product (days)*	*Average net Income/ day (checkpoint fees subtracted) (USD)*
Timber	52.6	51.4	3.20
Bamboo	31.7	6.4	3.10
Vine	2.1	6.7	2.60
Firewood	74.5	6.5	2.40
Bamboo hoot	8.3	2.8	2.10
Mushroom	3.1	16.6	0.50

5.0 RECOMMENDATIONS

In light of the high demand for forest products in Chumkiri District, the importance of these products to annual household income (38% of total income), the ongoing degradation of forest areas, and the current lack of forest management, we recommend:

- **Developing community forestry management through local participation to protect areas near villages for forest regeneration (especially near Cheiteal and Mononop villages).** With proper management, community forests could provide stable supplies of fuel wood, bamboo, and other NTFPs to nearby villages, thereby reducing the current health risks to villagers associated with longer trips to the forest. The villagers recognize the importance of forest resources to their livelihoods. If allowed local control over community forest areas, the villagers will have an incentive to manage these areas in a sustainable manner so that resources are available for future generations.

- **Applying the *Community Forest Guidelines* in the development of community forests.** The Royal Government of Cambodia adopted the *Community Forest Guidelines* in 2000. They provide a useful process for initiating and facilitating the development of community forests that should guide the integration of forestry and natural resource management into local planning processes.

- **Promoting home gardens in villages located far from forests (especially in Chress and Thmir villages).** Home gardens could help to meet the demand for NTFPs (e.g., bamboo for handicrafts) in these villages. To encourage successful home gardens, the villagers need technical assistance in several areas including nursery techniques, seedling preparation, and soil improvement methods. However, the technical assistance should also respect the villagers' traditional knowledge about home-gardening.

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Figure 1. Collecting Firewood by Ox Cart in Chumkiri District, Kampot Province

Figure 2. Collecting Firewood in Chumkiri District, Kampot Province

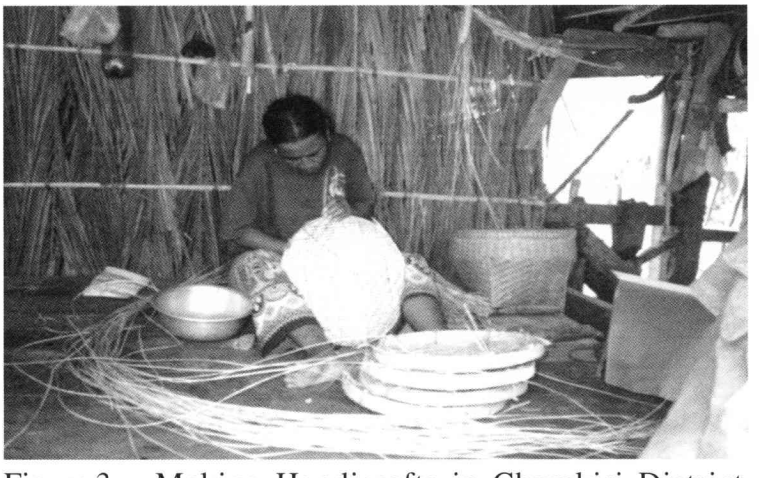

Figure 3. Making Handicrafts in Chumkiri District, Kampot Province

SURVEY ON ENVIRONMENTAL AND HEALTH EFFECTS OF AGROCHEMICAL USE IN RICE PRODUCTION IN TAKEO PROVINCE, CAMBODIA

Mary Chamroeun, Vann Kiet, and Sun Votthy

1.0 INTRODUCTION

Rice is grown by over 80% of the Cambodian population, mostly subsistence farmers in rural areas. In an effort to improve their livelihoods through higher rice yields, these farmers have increasingly turned to the application of chemical fertilizers and pesticides. However, few Cambodian farmers have had any training regarding the appropriate usage of these agricultural chemicals, resulting in sub-optimal improvements in yields and damaging environmental and health impacts.

1.1 Study Objectives

This study seeks to improve the available information on fertilizer and pesticide usage in Cambodia, particularly in areas of Takeo Province that is known for intensive agrochemical application. A key element of this effort is to assess the impacts of agrochemicals on the environment and human health. In addition, the study evaluates the costs and benefits of using agrochemicals from the perspective of both the farmer and society in general.

2.0 RESEARCH METHODS

A survey on the rice production, agrochemical practices, and environmental and health impacts was carried out between July and December 2000 in two villages - Prey Sva and Prey Tamao, Takeo Province. All the farmers who were interviewed were randomly selected. In Prey Sva, 85 farmers were surveyed of whom 37 cultivated *both* wet and dry season rice and 48 cultivated *either* wet or dry season rice. These 85 farmers represented 66% of Prey Sva's households. In Prey Tamao, 64 farmers were surveyed of whom 47 cultivated *both* wet and dry season rice and 17 cultivated *either* wet or dry season rice. These 64 farmers represented about 32% of Prey Tamao's households.

3.0 CHEMICAL FERTILIZER USE AND IMPACTS

As shown in Table 1, the application of fertilizer in Prey Sva and Prey Tamao depended significantly on the rice season — the usage of chemical fertilizers was more common in dry season rice production, whereas mixed and organic fertilizers were more commonly used for wet season rice production.

Table 1. Percentage of Farmers Applying Different Types of Fertilizers in Prey Sva and Prey Tamao, Wet and Dry Seasons 1999-2000

Types of Fertilizer	*% of Farmers in Prey Sva*		*% of Farmers in Prey Tamao*	
	Wet season	*Dry season*	*Wet season*	*Dry season*
Cow manure only	2	0	26	2
Mixed fertilizer (organic and chemical fertilizers)	98	2	30	38
Chemical fertilizer only	0	98	34	60
No fertilizer applied	0	0	10	0

Farmers applying chemical fertilizers often do so in amounts far exceeding the levels recommended by the Cambodia-IRRI-Australia Project and approved by the Ministry of Agriculture, Forestry and Fisheries. Table 2 shows the percentage of farmers applying chemical fertilizers in amounts above, within, and below the range recommended for the soil types of Prey Sva and Prey Tamao.

Table 2. Application of Chemical Fertilizers Compared to the Recommended Range of Application in Prey Sva and Prey Tamao, Wet and Dry Seasons 1999-2000

Level of Application	*% of Farmers in Prey Sva*		*% of Farmers in Prey Tamao*	
	Wet season	*Dry season*	*Wet season*	*Dry season*
Below the recommended range	9	29	57	43
Within the recommended range	38	47	29	21
Above the recommended range	53	24	14	36

The failure by most farmers to apply the recommended amount of chemical fertilizer appears to be due to a lack of information on soil types and recommended application ranges, lack of agricultural training, and the inability of farmers to understand fertilizer product label instructions because they are written in foreign languages. All farmers surveyed could not read fertilizer labels and few had ever received formal training in rice farming techniques.

Farmers may also be applying excessive levels of chemical fertilizers because they view this as necessary for maintaining or increasing rice yields. Nearly all farmers who were interviewed suggested that chemical fertilizers bring significant increases in yield in the first year of use, but that yield will fall steeply (below pre-chemical fertilizer yields) if chemical fertilizers are not applied in the following years.

All farmers who were surveyed also noted that long-term use of chemical fertilizers caused their soil to become hard and less fertile, making it necessary to apply more chemical fertilizers to maintain yields. Indeed, the analysis of fertilizer application data collected for this study indicates that, on average, farmers who have been applying chemical fertilizers for longer periods of time tend to apply a greater amount *than* farmers who have only recently begun using chemical fertilizers.

In addition to the impacts on soil fertility, all but one of the farmers surveyed felt that the use of chemical fertilizer reduces the quality of rice's taste, texture, and smell, which in turn can result in a lower selling price.

Finally, about 90% of the farmers surveyed noted that fish and aquatic species tend to be more abundant in rice paddies where organic, rather than chemical, fertilizers have been applied. This may be an indicator of the impact of chemical fertilizer on water quality. Given the importance of aquatic resources to food security and rural livelihoods, the relationship between chemical fertilizer use and aquatic resource health should be an important area for future study.

4.0 PESTICIDE USE AND IMPACTS

Similar to chemical fertilizer use, pesticide application in Prey Sva and Prey Tamao depended significantly on the rice season — pesticide use is more common during dry season rice production than wet season rice production (see Table 3). The most frequently used pesticides were insecticides, followed by rodenticides and herbicides.

Table 3. Percentage of Farmers Applying Pesticides in Prey Sva and Prey Tamao, Wet and Dry Seasons 1999-2000

Pesticide Application	*% of Farmers in Prey Sva*		*% of Farmers in Prey Tamao*	
	Wet season	*Dry season*	*Wet season*	*Dry season*
Pesticides applied	53	72	52	98
No pesticides applied	47	28	48	2

The World Health Organization (WHO) has classified pesticides by toxicity/hazard into Class I, II, and III with those in Class I considered the most toxic. Many countries including Cambodia have banned the use of pesticides classified as Ia or Ib.[2] Nonetheless, the use of Class I pesticides remains common in Cambodia. Findings from this study suggest that a high percentage of farmers applying pesticides in Prey Sva and Prey Tamao use Class I pesticides (see Table 4). Further, it appears that many farmers may be applying their pesticides (no matter what WHO class) in amounts that generally exceed the recommended application levels. However, this is difficult to determine with certainty because standards for pesticide application levels have not yet been developed in Cambodia.

[2] Among other restrictions on pesticide use, Cambodia's 1998 Sub-decree on Standards and Management of Agricultural Materials banned the use of WHO Class I pesticides.

Table 4. Percentage of Farmers Applying Pesticides Classified by World Health Organization, Prey Sva and Prey Tamao Villages, Wet and Dry Seasons 1999-2000

Pesticide Class as Designated by WHO	*% of Farmers in Prey Sva*		*% of Farmers in Prey Tamao*	
	Wet season	*Dry season*	*Wet season*	*Dry season*
Ia and Ib	30	56	14	34
II	60	39	71	40
III	10	0	0	13
Unknown	0	5	15	13

None of the farmers surveyed in Prey Sva and Prey Tamao had ever received training in the appropriate application of pesticides. Poor practices such as smoking and eating while spraying, spraying against the wind, and not wearing protective clothing are commonplace. As a result, pesticide-related health problems appear widespread. Approximately 70% of the farmers surveyed spray pesticides during the wet and/or dry season, of which about 30% reported experiencing pesticide-related health problems. These problems, which occurred during or soon after spraying, included fatigue and dizziness, headaches, fever and chills, diarrhea, stomachaches and vomiting, coughing, and eye and skin irritation. The farmers lost workdays due to these health problems in the range of 2 to 14 days per year and some farmers continue to experience health problems that they believe are pesticide related.

Most farmers spray pesticides when they notice their crops damaged by pests or see a large number of insects in their rice field. Since very few of the farmers interviewed can distinguish between beneficial insects and actual pests, some farmers may be spraying pesticides unnecessarily. It should also be noted that some farmers reported spraying pesticides when they see other farmers doing so, even if there is no evidence of crop damage or insects in their field. Such indiscriminate pesticide spraying may result in increasing pest resistance. Almost half of the farmers surveyed noted cases in which they have sprayed pesticides with no effect on the targeted pests. This may reflect an increased resistance by the pests or an ineffective pesticide.

Compounding the problems associated with a lack of training, all the farmers surveyed were unable to read pesticide instruction labels because all labels are written in foreign languages. Therefore, label information on the appropriate application, storage, and disposal practices is inaccessible to these Cambodian farmers. More than half of the farmers surveyed keep pesticides in their house without a safety cabinet. Almost half of the other farmers keep pesticides outside the house without a safety cabinet. Regarding the disposal of pesticide residuals, over 90% of farmers in Prey Sva and Prey Tamao dispose cans, bottles and wash sprayers in their rice fields and/or irrigated canals.

The overuse of pesticides and poor disposal practices also has an impact on fish and other aquatic resources. About 90% of the farmers surveyed in Prey Sva and Prey Tamao noted

that few, if any, aquatic resources live in rice paddies where pesticides have been sprayed. Some of the farmers also suggested that the abundance of aquatic resources in nearby lakes and rivers has declined, though this may also be due to reasons unrelated to pesticide poisoning (like over-fishing, electric shock fishing practices, and loss of flooded forests).

5.0 IMPACTS ON NET INCOME AND CAMBODIAN SOCIETY

The overuse of chemical fertilizers and dangerous pesticides can result in unnecessary costs for farmers and the Cambodian society. When farmers apply excessive or unnecessary amounts of agrochemicals (i.e. above the recommended amount), the agrochemical inputs have little effect on improving rice yields but may significantly reduce the farmers' net income due to costs associated with purchasing and applying these unnecessary inputs. In addition, poor practices in the application of agrochemicals can result in health problems, declining soil fertility, and reduced aquatic resources, all of which can seriously affect the farmers' income.

Although the effects of poor practices in the application of agrochemicals are significant on farmers, these impacts also extend to the Cambodian society. While a farmer who does not fish may not care about the impacts on nearby lakes and rivers due to his agrochemical use, these impacts represent real costs to the Cambodian society in the form of reduced water quality and aquatic resources. Likewise, while this study focuses on the impacts of pesticide use on farmers' health, it should be recognized that the Cambodian population is also exposed to many of these pesticide-related health problems by consuming food treated with pesticides. Finally, where the use of agrochemicals causes severe reductions in soil fertility, its impact on land productivity may be felt for generations.

6.0 RECOMMENDATIONS

- **Increase training and awareness about agrochemicals.** Increase the number of available training courses on agrochemical use. The issues covered should include the appropriate application of pesticides and chemical fertilizers (given different soil types), potential impacts of chemical fertilizers and pesticides to health, pest resistance, soil and water quality, awareness of banned pesticides, and possible alternatives to chemical fertilizers and pesticides (e.g., organic fertilizers, integrated pest management).

- **Promote agrochemical-free agricultural products.** Experiences in Western Europe and Cuba suggest that organic farming techniques can be competitive with agrochemical-based approaches. Markets for agrochemical-free agricultural products are growing rapidly as people become more concerned about the impacts of using/consuming agrochemicals. The Royal Government of Cambodia (RGC) should promote organic farming techniques by supporting training and identifying markets for organic agricultural products.

- **Improve agricultural research.** In order to carry out training activities about agrochemicals (recommendation #1) and promote organic farming techniques (recommendation #2), the RGC needs to improve agricultural research. The RGC should support the development of a laboratory for agricultural research capable of conducting analysis of soil, water, and plants. This laboratory's activities should be directed toward serving the practical research needs of Cambodia's farmers.

- **Enforce the ban on WHO Class I pesticide use.** In addition to awareness-building activities to improve farmers' understanding of banned pesticides, the RGC should comprehensively implement the 1998 Sub-decree on Standards and Management of Agricultural Materials banning the use of WHO Class I pesticides. As part of this effort, Cambodia should work closely with Vietnam and Thailand to reduce the flow of banned pesticides across borders. The RGC should also consider joining the Rotterdam Convention on Prior Informed Consent as a means for improving information on pesticide imports/exports.

- **Impose/Introduce Value Added Tax (VAT) and other taxes on chemical fertilizer and pesticide imports.** The RGC does not currently apply VAT and other taxes to the import of chemical fertilizers and pesticides. Removal of this "free of VAT and other taxes" provision would result in an increase in agrochemical prices, in turn reducing their use and importation. Applying the VAT and other taxes to agrochemical imports would also make organic fertilizers and methods more price-competitive, thus, encouraging farmers to use organic fertilizers and adopt pesticide-free techniques rather than use agrochemicals.

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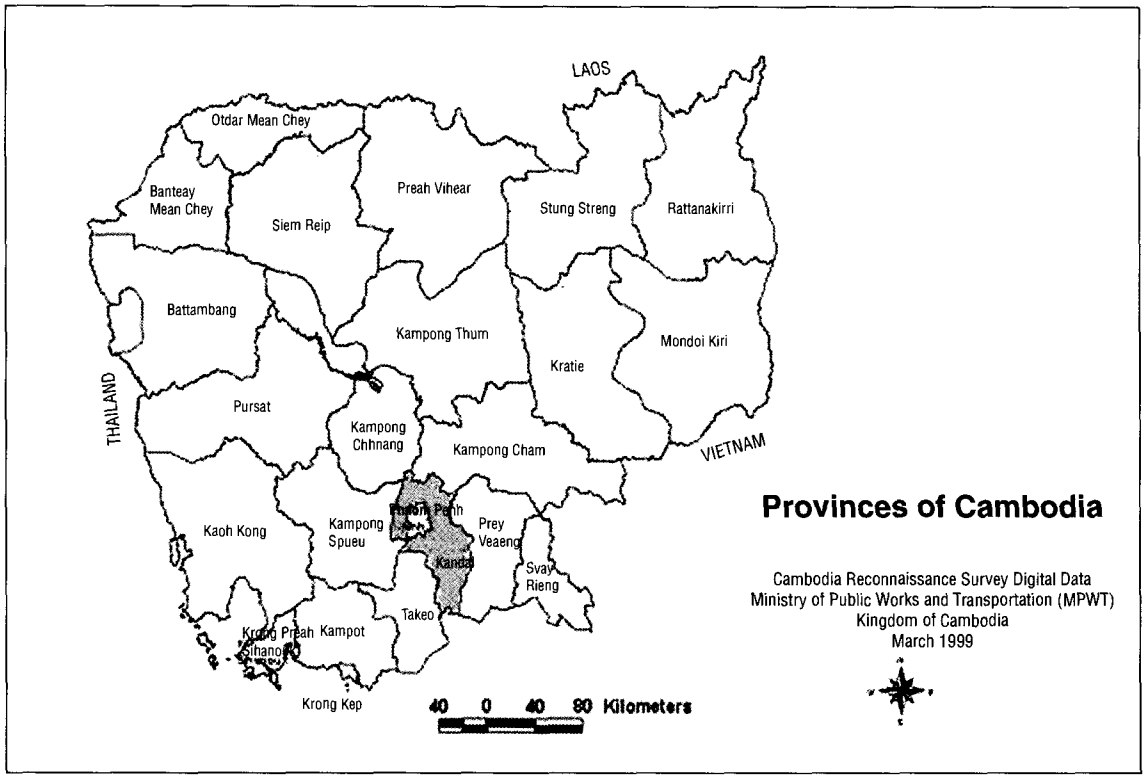

Location of Research Sites

Research on flooded forests and the *Mimosa pigra* weed was conducted in Kandal Province (shaded). Research on agricultural chemicals was carried out in Takeo Province and research on forest use was conducted in Kampot Province.

VALUATION OF FLOODED FORESTS IN KANDAL PROVINCE, CAMBODIA

Hap Navy, Thay Somony, and Hav Viseth

1.0 INTRODUCTION

Cambodia's vast floodplain ecosystem includes large areas of flooded forests — tree and shrub species that can withstand inundation for three to six months during seasonal flooding. It is estimated that about 80% of the flooded forests are located around Cambodia's Great Lake and the remainder along the Mekong River and other rivers. Flooded forests play a significant role in supporting aquatic life and rural livelihoods. They are vital as breeding grounds, nurseries and habitats for aquatic resources. Flooded forests also trap sediment during seasonal flooding and provide flood control benefits that support nearby agricultural activity. In addition, flooded forests support rural livelihoods by providing sources of fuel wood, handicraft materials, fruits, and traditional medicines.

In recent years, Cambodia's flooded forest areas have declined at an alarming rate. In 1985-87, flooded forests were estimated to cover an area of 795,400 ha, but by 1992-93 this area had dropped by more than half to 370,700 ha. While more recent data on flooded forests is unavailable, it is widely believed that since 1992-93 the loss of flooded forests has continued at a rapid pace. The loss has been largely due to increased land pressures that result in rapid conversion of forests for agricultural purposes and unsustainable fuel wood collection due to the strong demand from nearby urban areas.

1.1 Study Objectives

In light of the rapid decline in Cambodia's flooded forests, this study seeks to understand the possible economic motivations for the decline by comparing the net income provided by flooded forests with the net income from agricultural production on land that has been converted from flooded forests to farmland. The study also assesses rural people's perceptions of the reasons for flooded forest loss and their views on sustainable management.

2.0 RESEARCH METHODS

The two flooded forest areas selected for this study are located in four communes of Muk Kompul and Ponhear Leu Districts, Kandal Province. These study sites were chosen for their close proximity to Phnom Penh, the associated land and fuel wood collection pressures, and the presence of commercial fishing lots (Lot 12 in Muk Kompul and Lot 14 in Ponhear Leu).[3] Further, these sites were chosen for their differences in the quantity and quality of the flooded forests. Whereas 2,971 ha of somewhat degraded flooded forest remain in Muk Kompul, only 170 ha of severely degraded flooded forest remain in Ponhear Leu.

A survey on flooded forest management issues, net income from flooded forests, and net income from rice production on converted land was carried out between July and November 2000. Survey interviews were conducted with 49 households in two communes of Muk Kompul (Sambour Meas and Svay Ampear communes) and 58 households in two communes of Ponhear Leu (Samrong and Kompong Lourng communes). All the household interviews were randomly selected. The 107 households surveyed represented about 2% of the total households in the four communes.

3.0 NET INCOME FROM FLOODED FORESTS

In order to compare the productivity of flooded forests with agriculture, estimates of net income (cash and non-cash) were developed on a per hectare basis. While it may be straightforward to estimate the income from agricultural land, estimating the income derived from flooded forests can be quite complex due to the lack of information on how much fisheries depended on flooded forests. It is widely agreed that flooded forests support fisheries by providing breeding grounds, nurseries, and habitat and the removal of flooded forests has devastating effects on fisheries. However, no systematic study has been conducted to assess the strength of the correlation between flooded forest loss and fishery decline. For the purposes of this study, *all* fish catch income is attributed to the presence of the existing flooded forests. As this assumption likely overstates the income benefits of flooded forests, a "break-even" analysis is also conducted to determine the percentage of fish catch that would need to be dependent on flooded forests for the net income from flooded forests and agriculture to be equal.

As shown in Table 1, households in the districts of Muk Kompul and Ponhear Leu derive income from the flooded forest areas through small-scale fishing and fuel wood collection, and to a lesser extent wild vegetable collection. With an average annual catch of 203 kg per household, small-scale fishing accounted for the greatest proportion of income earned from the flooded forest in 1999-2000. Not surprisingly, the average annual income from fishing was higher in Muk Kompul (USD 92) where a significant flooded forest remains compared to Ponhear Leu (USD 66) where much of the flooded forest has been converted

[3] Fishing lots are auctioned by the Cambodian Government to the highest bidder for exclusive exploitation over a two-year period.

to agricultural land. Combining this fishing income with fuel wood and vegetable collection, the total net income per hectare of flooded forest was estimated to be about USD 140 in 1999-2000.

In addition to small-scale fishing, two commercial fishing lots are supported by the flooded forests in Muk Kompul and Ponhear Leu. Provincial Fisheries Office data for 1999-2000 suggests that the annual net income from these lots was about USD 70,000, equivalent to about USD 22 per ha of flooded forest. Since the Provincial Office relies on self-reporting from lot owners, and lot owners appear to have incentives to under report their catches, these net income estimates may be lower than the actual income earned. Accepting the estimate of USD 22 per ha of flooded forest, the total net income earned from the commercial fishing lots, small-scale fishing, and fuel wood and vegetable collection was about USD 162 per ha of flooded forest.

Of the households surveyed, 84% reported that they cultivate rice and/or other crops on land converted from flooded forests. Average rice yield was 2,268 kg in 2000, with production somewhat higher in Muk Kompul than Ponhear Leu. The annual net income per hectare from rice cultivation was USD 46, with an additional USD 31 earned from the production of other crops (primarily vegetables). The total net income from agricultural production of USD 77 per ha was well below that of the income derived from the flooded

Table 1. Net Income from Flooded Forest Resources in Muk Kompul and Ponhear Leu Districts, Kandal Province, 1999-2000

Flooded Forest Activity	*Percent of Households Engaged in Activity (%)*	*Average Annual Net Income Per Household Engaged in Activity (%) (USD)*	*Average Annual Net Income Per Household in the Two Districts [1] (USD)*	*Total Annual Net Income for All Households in the Two Districts [2] (USD)*	*Total Annual Net Income Per Hectare of Flooded Forest [3] (USD)*
Small-Scale Fishing	74.8	78.65	58.80	342,865	109.16
Fuel wood Collection	81.3	19.10	15.53	90,532	28.82
Vegetable Collection	24.3	4.87	1.18	6,898	2.20
Subtotal – Households		102.61	75.51	440,295	**140.18**
Commercial Fishing Lot				69,439	22.11
Total				509,734	**162.28**

[1] Average includes households surveyed that were not engaged in the livelihood activity.

[2] Based on an estimated total of 5,831 households in the two communes of Sambour Meas and Svay Ampear in Muk Kompul and the two communes of Samrong, and Kompong Lourng in Ponhear Leu.

[3] Based on an estimated total of 3,141 ha of flooded forest in Muk Kompul and Ponhear Leu.

forests which was USD 162 per ha. Under a break-even analysis, this suggests that if only 35% of the fish catch income is dependent on flooded forests (rather than the assumed 100%), the net income per hectare from the flooded forests equals that of agricultural production.

4.0 FLOODED FOREST BENEFITS

In addition to fish, fuel wood, and wild vegetable benefits, most of the households surveyed also recognized how flooded forests contributed to soil quality and flood control. For example, 70% of the households reported that their soil quality is becoming worse over time. They believe that the decline in soil fertility is in part occurring because the loss of flooded forests has reduced sediment trapping in the area during the flooding season.

Most households (75%) also appear to be aware of current regulations prohibiting the conversion of the flooded forests to agricultural land. However, they note that poverty, landlessness, joblessness, and a perception of unlimited flooded forest resources result in continued flooded forest conversion.

5.0 RECOMMENDATIONS

The estimates from two districts in Kandal Province suggest that flooded forests provide greater overall income benefits per hectare than agricultural production. Recognizing this fact, recommendations focus on encouraging further study of the importance of Cambodia's flooded forests and improving flooded forest management.

- Conduct an inventory and examination of the remaining flooded forest areas to support a broader strategic plan for sustainable flooded forest management.

- Conduct further studies of the economic benefits from flooded forests, especially around the Great Lake where an estimated 80% of flooded forests are located.

- Promote local participation in flooded forest conservation and management, transfer management responsibilities for the flooded forests to communities and local authorities, and support stricter enforcement by the Department of Fisheries and other institutions to stop illegal cutting of flooded forests.

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Figure 1. Firewood Collection from A Flooded Forest, Kandal Province

AN INVESTIGATION ON THE IMPACTS OF *MIMOSA PIGRA* ON RICE AND FISHERY PRODUCTIVITY IN KANDAL PROVINCE, CAMBODIA

Keo Chamroeun, Teng Peng Seang, Hor Sophal, Seng Sun Hout, and Has Vuthy

1.0 INTRODUCTION

Mimosa pigra is a prickly shrub with a fern-like appearance and pink flowers. It grows in dense stands and is known for its ability to aggressively colonize flooded plains and other seasonally inundated areas. Producing approximately 10,000 seeds per square meter, *Mimosa pigra* can quickly spread to new locations through seasonal flooding. Moreover, *Mimosa pigra* produces seeds in its first year of growth and can grow at a rate of one cm per day to heights of six meters. With roots that extend 1-2 meters into the soil, the removal of *Mimosa pigra* is notoriously difficult and labor intensive. Complete removal is often not possible. Common removal techniques, such as cutting and burning, do not remove all of the roots, thereby allowing *Mimosa pigra* to grow back the following year.

In Cambodia, *Mimosa pigra* has rapidly proliferated in inundated zones since the early 1990s, raising concerns about its impact on agriculture, fishing, and flooded forests. The invasion of *Mimosa pigra* can reduce land availability for agricultural production, increase costs for farmers to remove the weed from their land, and result in less productive fisheries due to decreases in fishery habitat and reduced access to fishing areas.

1.1 Study Objectives

This study focuses on the impacts of *Mimosa pigra* proliferation in Kandal Province, Cambodia, a lowland area located about 13 km from Phnom Penh where rural people subsist largely on rice and fish. The annual flooding of the Mekong, Bassac and Sap Rivers, which all flow through Kandal, has facilitated the rapid spread of *Mimosa pigra* in many areas of the province. A dramatic increase in the cutting and conversion of Kandal's flooded forests for rice production over the past fifteen years has also aided *Mimosa pigra* proliferation by opening up areas and reducing competition from other flora. Kandal's flooded forests have decreased from an estimated 61,359 ha in 1985 to 5,275 ha in 1998-99.

The objective of this study is to evaluate the impact of *Mimosa pigra* on rice farming and fishery productivity in Kandal province. Specifically, the study estimates *Mimosa pigra* removal costs for farmers, assesses the potential impacts of *Mimosa pigra* on rice yields, and investigates how the spread of *Mimosa pigra* may reduce fish habitats and thereby affect the productivity of fisheries.

The study found that rice farmers incur significant costs in removing *Mimosa pigra* from their fields. In some cases, these represent a loss of nearly half of their net revenues. Infestations may also inhibit the regeneration of the flooded forests and affect fish catch. The magnitude of the latter two effects was more difficult to quantify and a further research is recommended. The study recommends, among other things, that measures be taken to conserve flooded forests as a way of controlling the spread of *Mimosa pigra*.

2.0 RESEARCH METHODS

Over the course of the study (from May 2000 to June 2001) two surveys were carried out in Kandal to collect primary data on *Mimosa pigra*'s impact on rice farming and fisheries. The rice farming survey was conducted in eight villages — Koh Ras, Svay Ampir, Boeung Chhonlén, and Kday Chhas along the Mekong River, Toul Sala and Prek Ksav along the Bassac River, and Toul Ampil and Pormongkul along the Sap River. Villages were selected for their proximity to the rivers and fishing lots, and were based on assistance from Commune Chiefs and the Office of Agriculture in each district. The survey was conducted on 158 households, which represented about 6% of the total households.

The villages in which the rice farming survey was conducted are located next to 19 fishing lots, whose ownership is subdivided among 164 lot owners. A second survey was conducted with 16 of these lot owners (representing 16 of the 19 fishing lots) to investigate whether the rapid spread of *Mimosa pigra* in recent years had affected fishing lot productivity. As it was beyond the scope of this study to track changes in the fishery productivity over time, this survey relied primarily on the information as recalled by the lot owners. Through interviews, the survey sought to understand the lot owners' opinions on how and why fishery productivity has changed over recent years, taking into account the numerous factors other than *Mimosa pigra* that can affect the health of fisheries, such as sedimentation, water quality, illegal fishing, and disease.

3.0 *MIMOSA PIGRA* REMOVAL COSTS FOR RICE FARMERS

The spread of *Mimosa pigra* caused significant hardships for many farmers in Kandal Province. More than 40% of the rice farmers surveyed indicated that *Mimosa pigra* on their rice land was a "serious" problem in 2000, whereas only 10% of the farmers recalled *Mimosa pigra* being a serious problem in 1995. An additional 25% of the farmers noted that *Mimosa pigra* was a "slight" or "moderate" problem in 2000. Overall, the farmers ranked *Mimosa pigra* as the most significant problem affecting rice farming, ahead of pests, rodents, and drought problems.

Farmers with *Mimosa pigra* on their rice land incur labor costs to remove it prior to rice planting. Table 1 provides a summary of data collected on the total farming input costs, *Mimosa pigra* removal costs, and returns from rice yields for four villages adjacent to the Mekong River and four villages adjacent to the Bassac and Sap Rivers. Results are also

presented according to the farmers' total land size to assess whether *Mimosa pigra* removal costs were proportionally a greater burden for small farmers (farm land less than 0.5 ha) than large farmers (farm land greater than 1.0 ha).

As shown in Table 1, the survey data indicated that *Mimosa pigra* imposed a significant cost on Kandal's farmers in 2000, especially on those farming along the Mekong River. On an average, *Mimosa pigra* removal costs represented about 5-10% of the total farming input costs. These costs had a major impact on the farmers' net revenues, representing a loss of close to half of net revenues in some cases. The removal costs per hectare were generally similar across small and large farms in the eight villages.

Table 1. Impact of *Mimosa Pigra* Removal Costs on Rice Farming Revenue in Kandal in 2000.

Land size	*No. of HHs*	*Total farming input costs per ha (riels)*[1]	*MP removal cost per ha (riels)*[2]	*MP removal cost/ total input costs (%)*	*Total revenue per ha (riels)*	*Net revenue per ha (riels)*	*Net revenue per ha if HHs had not incurred MP costs (riels)*
Mekong River Villages							
Small (< 0.5ha)	17	925,205	91,468	9.9	1,027,030	102,498	193,966
Medium (>= 0.5ha and < 1.0ha)	20	854,231	74,977	8.8	1,109,395	255,164	330,141
Large (> 1.0 ha)	40	730,920	58,471	8.0	816,565	85,645	144,116
Tonlé Sap/Bassac River Villages							
Small (< 0.5ha)	30	975,542	40,573	4.2	1,113,597	138,055	178,628
Medium (>= 0.5ha and < 1.0ha)	30	895,909	53,365	6.0	1,030,85	134,176	187,542
Large (> 1.0ha)	21	756,329	46,000	6.0	741,456	-14,873	31,127

[1] 4000 riels = 1USD. Total input costs include *Mimosa pigra* removal costs and other labor costs.

[2] Reflects labor hours to remove *Mimosa pigra* multiplied by average labor wage rate of 3,000 riels per day.

4.0 IMPACT OF *MIMOSA PIGRA* ON RICE YIELD

This study also investigated *Mimosa pigra*'s potential impact on rice yields in areas where *Mimosa pigra* had been removed for rice planting. Since the roots of the *Mimosa pigra* often remain after removal, it is possible that the roots compete with rice plants for water and nutrients, thereby reducing the productivity of the rice plants.

To test this hypothesis, the study assessed how the farmers' rice yield per hectare in 2000 varied with their input costs and *Mimosa pigra* removal costs using a regression analysis. If *Mimosa pigra* roots were affecting the productivity of rice plants, farmers who incur higher removal costs per ha should also experience lower yields. However, this study's regression analysis found no evidence of a significant relationship between *Mimosa pigra* removal costs and rice yield.

Given the limited scope of this study, it is recommended that the possible relationship between *Mimosa pigra* and rice yield be investigated further. Future research might be designed as a controlled experiment rather than depend on household survey results. For example, the research might compare yields from a rice field where a known amount of *Mimosa pigra* was removed, with that from a rice field where no *Mimosa pigra* was ever present, controlling other variables where possible (i.e. similar soil fertility in rice fields, equal inputs of labor, capital, water, etc.).

5.0 OTHER IMPACTS OF *MIMOSA PIGRA*

About 40% of the households surveyed reported that *Mimosa pigra* caused problems to irrigation canals. Where the density of *Mimosa pigra* in canals were high, it reduced the flow of water to rice paddies. Further, the dense stands of *Mimosa pigra* drew considerable water from the canals, resulting in shallower canals and less water overall for rice paddies.

In addition, close to 60% of the households believed that *Mimosa pigra* had a negative impact on flooded forests. They noted that the flooded forests were unable to grow back in areas where *Mimosa pigra* grew. They were concerned about the health of the flooded forests because they recognized the importance of flooded forests as fishery habitats, for soil trapping and fertility, and for flood protection. In addition, many households collected fuel wood and other resources from flooded forests.

The households were also asked to identify any benefits they received from *Mimosa pigra*. The survey found little evidence of any benefits. About 25% of the households occasionally used *Mimosa pigra* as fuel wood, but they indicated that it was poor quality fuel. The households also noted that cattle would not eat *Mimosa pigra*.

6.0 IMPACTS OF *MIMOSA PIGRA* ON THE PRODUCTIVITY OF FISHERIES

The proliferation of dense *Mimosa pigra* stands in the fishing lots may be reducing fishery productivity by decreasing the amount of suitable habitat for feeding and reproduction, especially for fish species without scales. These fish have less protection against the thorns of the *Mimosa pigra* plants, making their access to habitat invaded by *Mimosa pigra* more difficult than for fish species with scales.

To investigate the potential impacts of *Mimosa pigra* on fishing lot productivity, 16 lot owners representing 16 different fishing lots in the study area were interviewed. These lot owners cited several reasons for fluctuations in fish catches over the past several years including illegal fishing activities, loss of flooded forest areas, increase in *Mimosa pigra*, and shallow water/ drought. However, while fish catches have fluctuated, all 16 lot owners noted a steady decline in the proportion of fish species without scales in their annual catches. On average, the proportion of fish species without scales in their annual catches dropped by about 10% from 1994 to 1999 - i.e. from about 28% to 18% of the total catch (see Figure 1).

Fishing lot owners suggested that rapid clearing of flooded forests in the early to mid-1990s, followed by increasing *Mimosa pigra* in these cleared areas, may be negatively affecting productivity of fish without scales. However, due to the wide variety of factors that can affect fishery productivity, and the possible problems associated with relying on recall information, it is difficult to draw strong conclusions about *Mimosa pigra*'s impact. To strengthen the findings about the possible impact of *Mimosa pigra* on fishery productivity, future research might closely track fish catches over time in specific fishing lot areas where *Mimosa pigra* has begun proliferating.

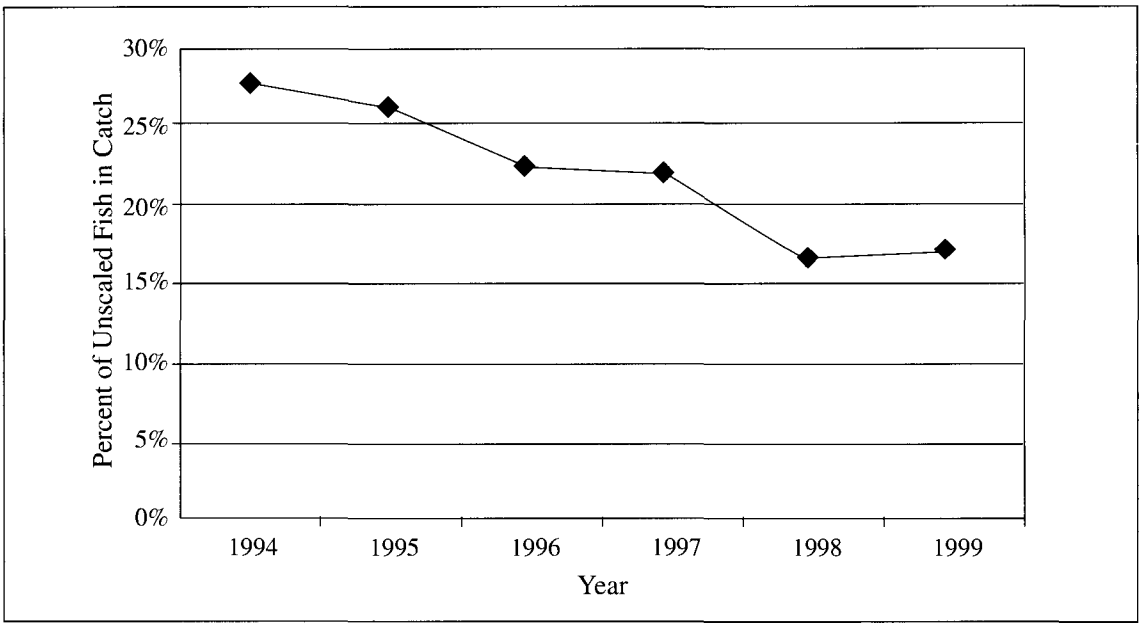

Figure 1. Proportion of Unscaled Fish in Total Annual Fish Catch for 16 Fishing Lot Owners in Kandal Province

7.0 RECOMMENDATIONS

Based on the above findings, this study recommends that the Royal Government make an increased effort to conserve and reforest flooded forest areas because the presence of flooded forests tends to reduce the encroachment and proliferation of *Mimosa pigra*. Specific recommendations include the following:

- **Introduction of Flooded Forest Community Management** — Community management structures similar to those being implemented by communities dependent on dry land forests, should be developed by/for communities dependent on flooded forests with support from the Royal Government and relevant non-governmental organizations. These management programs should encourage reforestation of cleared flooded forest areas where possible.

- **Increase Diversification and Intensification of Agriculture** — To encourage farmers not to clear flooded forest areas for rice cultivation, the government should support the introduction of more diversified and intensive agricultural practices so farmers can produce higher value crops and greater yields on less land. However, such programs must be careful about introducing or encouraging increased use of chemical fertilizers and pesticides due to the potentially negative impacts of their run-off on fisheries.

- **Support Flooded Forest Conservation to Control *Mimosa Pigra*** – This study found no evidence of chemical control of *Mimosa pigra* in Cambodia. As chemical control options are likely to cause negative impact on Cambodia's fisheries, these options should not be pursued. Rather, the conservation and reforestation of flooded forests should be encouraged to prevent *Mimosa pigra* proliferation.

- **Strengthen Land-Use Laws (especially as they relate to flooded forests) and Establish a *Mimosa Pigra* Task Force** — Remaining flooded forests should be protected under the forthcoming Immovable Properties Law ("Land Law") and Forestry Law. Implementation of these laws will require clear delineation of flooded forest areas and increased regulatory and enforcement measures. However, these laws should allow for sustainable community management of flooded forest areas where possible, as described in recommendation #1. To raise the profile of the problems caused by *Mimosa pigra* within the Royal Government, a task force should be created to address *Mimosa pigra* impacts around the Tonle Sap ("Great Lake") and within the Mekong River Basin.

- **Increasing Awareness about the Importance of Flooded Forests** — Simply declaring that it is against the law for people to clear flooded forest areas may not be enough by itself to protect flooded forests. Informational materials and training programs should also be developed to increase awareness among farmers on the importance of flooded forests. To reach farmers, such awareness-building efforts might be incorporated in existing/future rural credit programs and/or farmer cooperative organizations.

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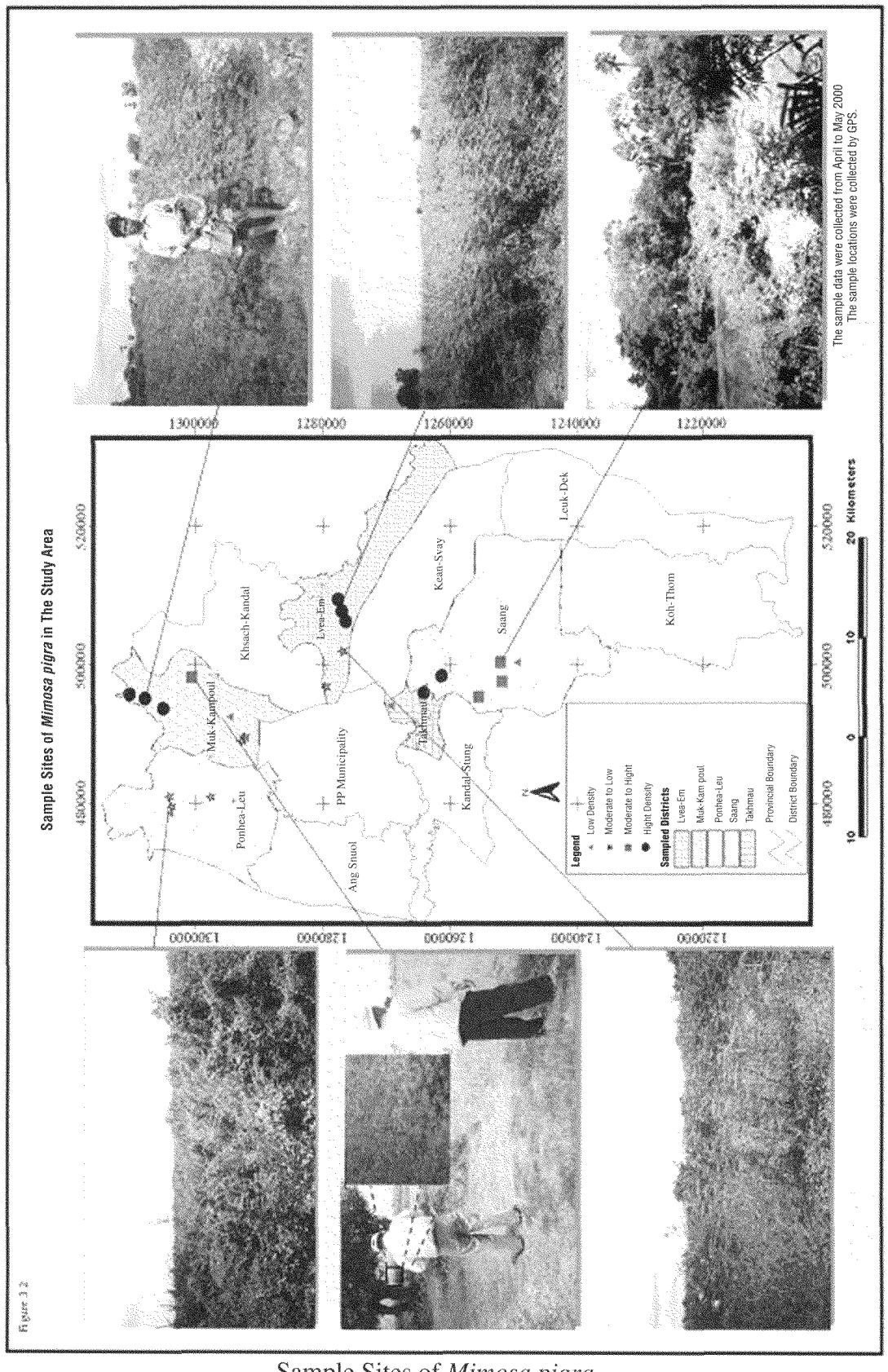

Sample Sites of *Mimosa pigra*

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