Economic Valuation of Aquatic Resources in Siem Reap Province, Cambodia

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ABSTRACT. The direct values of aquatic resources (freshwater) used in livelihood activities by rural households in Siem Reap, Cambodia were estimated using the net economic value method. The constraints faced by households to access these resources were also analyzed. Data used were from cross-section household survey, longitudinal monitoring, and participatory rural appraisal activities done among selected households from 2003 to 2004. In general, the study found that aquatic

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resources had substantial value in terms of income, employment, and overall livelihoods to households in both extractive and non-extractive activities. Among others, the study found that (1) fish catch per household was higher in the dry season than in the wet season and among higher wealth households than medium and lower wealth households; (2) livelihood activities earned positive net incomes even when labor was included as part of costs; (3) generally, labor formed a significant part of the costs of livelihood activities; and (4) the presence of fishing lots was the main access issue facing households in the use of aquatic resources. The study explored the implications of the results to the management and sustainable development of aquatic resources in Siem Reap. doi:10.1300/J064v31n01_10

KEYWORDS. Aquatic resources, economic valuation, net economic value method, rural livelihoods

INTRODUCTION

Background

This paper presented an economic valuation of aquatic resources in Siem Reap province, Cambodia. Aquatic resources were defined as freshwater fish, aquatic plants, aquatic animals, and aquatic wood that were harvested by households for livelihood purposes, as well as the water itself that was utilized by households for the provision of public transportation. This study used the market-based net economic value (NEV) method of economic valuation that takes the difference between total revenues and total costs of livelihood activities as measure of economic value.

The paper was one of the outputs of the Aquatic Resources Valuation and Policies for Poverty Elimination in the Lower Mekong Basin Project (Israel et al., 2005a,b). The project lasted from January 2003 to March 2005, was funded by the Department for International Development (DFID) of the United Kingdom, and implemented by the WorldFish Center in partnership with the Department of Fisheries (DOF) of Cambodia. The long-term goal of the project was to contribute to reducing poverty and improving livelihoods of the poor people

dependent on aquatic resources in the Lower Mekong Basin countries, particularly Cambodia.

The specific objectives of the paper were to (1) measure the production of fish and aquatic plants and animals among households in selected rural villages of Siem Reap; (2) quantify the direct value of aquatic resources used in various livelihood activities by households; (3) assess the constraints faced by households to the access to aquatic resources; and (4) derive conclusions and implications based on the results. The paper hypothesized that aquatic resources in general contributed positively to household income and employment in the rural areas and were important to households not just in fishing but also in various other extractive and non-extractive livelihood activities.

Background of Cambodia and Siem Reap

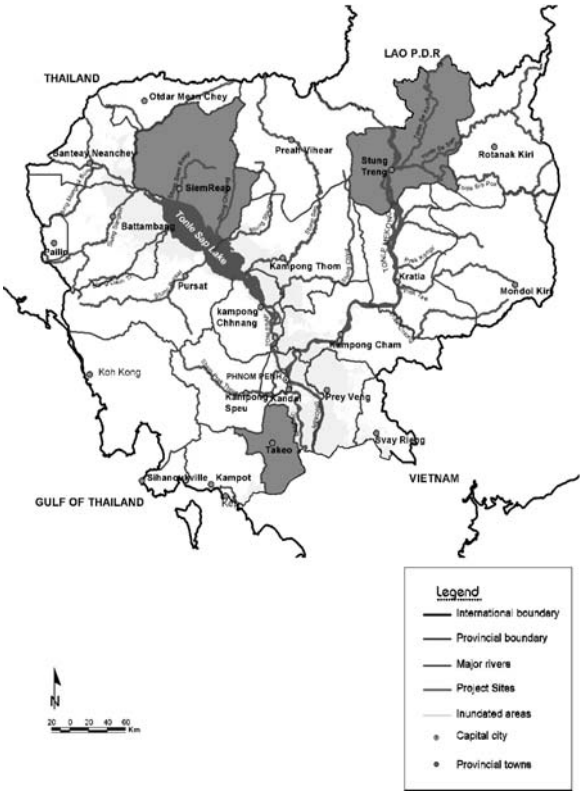
Cambodia is located in Southeast Asia. It is bordered in the west and northwest by Thailand, in the east and southeast by Vietnam, in the northeast by Lao PDR (People's Democratic Republic), and in the southwest by the Gulf of Thailand (Figure 1). Its climate is tropical with the wet season generally from May to October and the dry season from November to April. Most of the country comprises low and flat plains with mountains in the southwest and north regions.

The floodplains and other freshwater resources of Cambodia are immense in terms of area coverage. However, these resources have decreased over time, from about 1.87 million hectares in 1985-87 to 1.69 hectares in 1992-93 (Ahmed et al., 1998). Flooded forests, in particular, have experienced severe reduction, from approximately 0.80 million hectares in 1985-87 to 0.37 million hectares in 1992-93 alone.

The average annual gross domestic product (GDP) of Cambodia was 8.2 trillion riels between 1993 and 2001 or US$2.05 billion at the current exchange rate of US$1 = 4,000 riels. The GDP grew steadily at 5.7 percent per annum over the same period (NIS, 2002). GDP growth was retarded during the Asian regional economic crisis of 1997 and 1998 but recovered quickly. Annual GDP per capita averaged 715,000 riels or about US$179 from 1993 to 2001 and grew by approximately 1.5 percent per year.

By sector, the Cambodian economy was dominated by agriculture, fisheries, and forestry that collectively contributed an annual average of 3.7 trillion riels or US$925 million to the GDP from 1993 to 2001. Agriculture, which was mainly crop production, contributed most to sectoral

FIGURE 1. Map of Cambodia highlighting the Provincial Sites of the Project.



GDP, followed by fisheries and forestry. Approximately 73 percent of the fisheries GDP were from inland fisheries.

Approximately 9 million or 82 percent of the population in Cambodia lived in the rural areas (Table 1). The average household size was 5.3 persons and slightly lower for rural areas than urban areas. The female population was a little higher than males population. The age dependency ratio was about 77 percent. The official unemployment rate was 0.6 percent, whereas the average monthly income was 79,000 riels or about US$20. The average monthly income was significantly lower in the rural areas than in Phnom Penh and urban areas.

The province of Siem Reap had 12 districts, 100 communes, and 882 villages. With a total population of 696,164 people in 1998 and an area

TABLE 1. Selected demographic and socioeconomic indicators of Cambodia, 1999.

Indicator	Phnom Penh	Other urban	Rural	Cambodia
Population (millions)	0.96	1.17	9.43	11.60
Number of households ('000)	174	215	1,780	2,170
Household size	5.50	5.40	5.30	5.30
Percentage of female population	51.9	51.8	51.6	51.6
Age dependency ratio	57.0	77.1	79.1	76.8
Adult literacy rate	87.3	72.0	69.2	71.2
Unemployment rate	0.50	0.40	0.60	0.60
Monthly income per person (in riel)	220,000	99,000	63,000	79,000

Source: Adapted from NIS (2000).

of 10,300 square kilometers, the province had a population density of about 68 persons per square kilometer. The other important indicators of the province are presented in Table 2.

Siem Reap has vast natural resources, including upland forest resources of 422,082 hectares, flooded forests of 90,833 hectares, freshwater bodies of 5,017 hectares, agricultural land of 400,469 hectares, grassland of 55,236 hectares, and other lands of 80,805 hectares. The main body of water in the province is part of Tonle Sap Lake, which is the largest lake in Southeast Asia.

With the Tonle Sap Lake, Siem Reap is one of the richest provinces in Cambodia in terms of inland aquatic resources. In addition, the province has large floodplain areas and other freshwater bodies. Given these vast aquatic resources, it is understandable that a significant proportion of the Siem Reap population depends on these for subsistence and income generation. Of the approximately 3 million people in the Tonle Sap basin, it was estimated that around half relied on the Tonle Sap lake and its associated wetlands for their livelihoods (ADB, 2003).

Although inland aquatic resources are highly abundant in the Tonle Sap area, Siem Reap province remains highly impoverished. In general, the Tonle Sap Basin had the highest incidence of poverty, at 38 percent, among all the regions of Cambodia (Keskinen, 2003; MoP, 1999). In addition, the proportion of landless rural households in the area was the highest in the entire country, at 17 percent. This combination of poverty and landlessness drove the poor population to intensively exploit open-access aquatic resources.

TABLE 2. Selected demographic and socioeconomic indicators of Siem Reap Province, Cambodia, 1998.

Indicator	Statistic
Population ('000)	696
Land area (Sq. Km.)	10,300
Population density (P/Sq. Km.)	67.6
Number of households	127,000
Household size (Persons/Household)	5.40
Female household heads (%)	27.6
Migrant population (%)	1.80
Unemployment (%)	4.60
Access to safe water (%)	13.4
Access to sanitation (%)	10.7
Access to electricity (%)	9.40
Child malnutrition (%)	47.2
Male literacy rate (%)	63.9
Female literacy rate (%)	43.1

Source: Adapted from NIS (1999).

Review of Related Literature

Studies on inland aquatic resources and rural livelihoods in Cambodia and the Tonle Sap area exist (e.g., Keskinen, 2003; ARMP, 2000; Gum, 2000). Furthermore, a number of works have been conducted that estimated the economic value of aquatic resources in the country. Bann (1997a) conducted an economic valuation of the alternative mangrove management strategies in Koh Kong Province using mainly the net economic value (NEV) method. The study found that local fishing benefit per hectare of mangrove area was at about US$84 while benefit in terms of fuel wood was at US$3.50 per hectare. The study further found that shrimp farming was not only environmentally unsustainable but also financially unprofitable with farms typically being abandoned after 5 years of operation.

Bann (1997b) conducted another economic valuation study using the NEV method on tropical forestland use options in Ratanakiri Province. The study found that the benefits from the traditional sustainable use of forest resources exceeded the benefits from commercial timber

extraction in the study area by at least US$200 per hectare indicating that said areas, especially those with high cultural value and environmental significance, might best be managed by local communities. Hap et al. (2001) employed the NEV method to assess the value of flooded forests in Kandal Province. The results indicated that flooded forest resources had significant benefits in terms of fishing, fuel wood, and vegetable production and were more profitable as they were, to the local population, as compared with when they were converted for other uses, such as for agriculture.

Sy et al. (2002) conducted a valuation study on forest use in Chumkiri District, Kampot Province, again using the NEV method. The study found that the net income from forest-dependent activities of local households was significant and formed about 38 percent of the total income. Chamroeun et al. (2002) assessed the environmental and health effects of agrochemical use in rice production in Takeo Province using the productivity change approach and human capital approach. Although the costs were not quantified, the study found that agrochemical use resulted in negative health effects on farmers, lower fish productivity in the rice paddies, and higher production costs in rice farming.

De Lopez et al. (2001) used Contingent Valuation (CV) techniques to analyze policy options for the Ream National Park in Cambodia and found that the park was critical to the livelihood of local communities, the existence of trawlers and illegal fishing operators threaten the livelihood of local communities, and the willingness-to-pay particularly of foreign tourists for a boat ride in the park was high, indicating the great potential of the park as a tourist destination. Roudy (2002) conducted a study on the natural resource use and livelihood trends in the Tonle Sap floodplains mainly using the NEV method and found that the area significantly contributed to the livelihood of the communities there in addition to the contributions of the area to the national economy. This study, however, did not quantitatively measure the contributions of resources based on their numerous uses at the household and village levels.

In summary, the literature on economic valuation of aquatic resources in Cambodia generally concentrated on the fishing and wood extraction activities. There was only one study (Roudy, 2002) that conducted valuation in the Tonle Sap area where Siem Reap is located. Beyond fishing and wood gathering, the economic value of aquatic resources to a wide range of livelihood activities has not been well investigated in the Tonle Sap. The need for economic valuation is increasing with ongoing and planned economic development involving aquatic resources and

livelihoods within Cambodia and the Tonle Sap area (ADB, 2003; TSEMP, 2003).

MATERIALS AND METHODS

Overall, the project had three provincial sites in Cambodia: Siem Reap in the west near the Thailand border, Stung Treng in the north besides the Lao PDR border and Takeo in the south bordering Vietnam (Figure 1). The three provinces were selected based on various considerations, including their diverse aquatic resources and varying aquatic resources-based livelihood activities. Within Siem Reap, six villages in three communes were covered by the project (Table 3). All the communes and villages bordered the Tonle Sap Lake.

For this paper, the data used were from the cross-sectional household survey, longitudinal monitoring, and participatory rural appraisal (PRA) activities done by the project in the villages covered in Siem Reap. The household survey covered all the six villages mentioned earlier. Personal interviews were conducted using a prepared questionnaire and information generated on the demographic, socioeconomic, and other relevant characteristics of the households, their use of aquatic resources and the constraints that they faced to the access to the aquatic resources.

TABLE 3. Household population and household samples in the villages covered in Siem Reap, 2003-2004.

Communes/Villages covered by survey	Household population	Household sample	Sample/ Population (%)
Kampong Khleang Commune			
Ou Ta Putt Village	245	30	12
Chamkar Youn Village	155	30	19
Prek Sromoach Village	297	30	10
Kampong Phluk Commune			
Kok Dol Village	154	30	19
Dey Krohram Village	153	30	20
Kaev Pour Commune			
Peam Ta Our Village	227	30	13
Total	1,231	180	15

The survey was conducted from September 2003 to November 2003. Each household surveyed was classified as lower, medium, or higher wealth households based on various criteria developed by the villagers during focus group discussions (Israel et al., 2005b). From the population of each wealth type in each village, a sample of 10 households was randomly selected for a total of 30 households per village and 180 households in the 6 villages. The total sample of households was 15 percent of the total population of households in the six villages covered (Table 3). The size of the sample was constrained by the resources available and the far distance of the provinces, communes, villages, and households covered by the project. The uniform sample of 30 households per village and 10 households per wealth type per village was decided to generate equal representation among wealth groups and villages. The data on access constraints presented in this paper were generated from the household survey.

For the longitudinal monitoring, only one of the three communes, Kampong Khleang commune, and its three villages were included. In each village, the household population was again classified into lower, medium, and higher wealth households. In each village, two households were randomly selected for monitoring each wealth type–a total of 6 households per village and 18 in the province. As in the case of the household survey, the number of households covered by the longitudinal monitoring was limited by available resources and the need to spread out resources to cover a full year of monitoring activity. The longitudinal monitoring involved household respondents filling in a questionnaire weekly for a period of one year from November 2003 to October 2004, covering a complete cycle of wet and dry seasons. The data on the quantity of the output of activities performed on a regular basis for a whole year by the households by wealth type, specifically fishing and the gathering of aquatic plants and animals, were collected through longitudinal monitoring. The economic valuation and analysis of production of fish and aquatic plants and animals also used longitudinal monitoring data.

Both the household survey and longitudinal monitoring questionnaires were pre-tested before they were administered by formally trained enumerators coming from the staff of the provincial offices of the DOF and field workers of participating nongovernment organizations in the province. The data gathered were verified through revisits and further interviews at the village sites conducted by the enumerators.

PRA techniques, particularly key informant interviews, focus group discussions, and personal observations were conducted at the same time

that the longitudinal monitoring was done from November 2003 to October 2004. PRA methods were used to gather data on the inputs of production of the regularly conducted activities, the prices of the inputs and outputs, and the inputs and outputs of the activities that were seasonally or irregularly conducted. The seasonally or irregularly conducted activities included fish culture, fish processing, gathering of aquatic wood, and provision of public water transportation. Question guides and other materials were prepared for the conduct of focus group discussions and other PRA activities. Those who gathered the data and information included again the provincial DOF staff and field workers from participating nongovernment organizations. This group was likewise trained before conducting the PRA activities. The gathered data were also verified through revisits and further interviews at the sites conducted by the enumerators. The economic valuation done in the paper used quantity and price of inputs data gathered through PRA.

Theoretical discussions on economic valuation applied in the analysis of the natural resources and environment abound in the literature. More recent works with explanations of the different economic valuation methods applicable in the study of aquatic resources included Barbier et al. (1996), IIED (1997), De Lopez et al. (2001), CEMARE and SUIFAR (2002). The economic tool used in this study was the market-based approach of the NEV. Non-market valuation was not employed for some reasons. The project covered rural villages where many of the households belonged to low-income groups. Thus, willingness-to-pay and willingness-to-accept values for changes in natural resources and the environment for these households were likely to be low and not reflective of what they would be if the income constraints did not exist. Furthermore, research on economic valuation was new in the sites covered. Since part of the intention of the project was capacity building by way of training local government and nongovernment organization counterparts in economic valuation, a straightforward market-based approach was deemed appropriate.

The *NEV* from an economic activity, such as the exploitation of an aquatic resource, was defined as

$$NEV = TR - TC$$

where on a seasonal or annual basis, *TR* was the total revenue, or the quantity of output generated from the exploitation of the resource multiplied by its market price, and *TC* was the total costs that included both the financial (quantity multiplied by the market price of the material inputs,

hired labor and other purchased cost items) and the nonfinancial costs (quantity and market price of the unpurchased material inputs, such as household labor and other unpurchased items). The term "economic" was used to make a distinction from the term "financial" that purely meant the accounting of the money costs and returns to production.

Note that the use of the NEV method has important limitations. First, the prices of the outputs or inputs involved can be underestimated when they were home consumed or provided. Underestimation can likewise occur even when outputs and inputs were traded in formal markets but distortions such as monopolies, subsidies, poor information, and other market imperfections exist. Thus, extra care was needed so prices reflected those of undistorted or freely functioning markets. Second, the NEV approach only estimated the direct-use values of aquatic resources. Indirect uses of resources (such as the breeding and nursing of aquatic species) and non-use values (such as environmental services) were not estimated using the approach. Therefore, results of this analysis provided lower-bound estimates of the value of aquatic resources-based activity. The estimation of indirect and non-use values of aquatic resources were issues for further research.

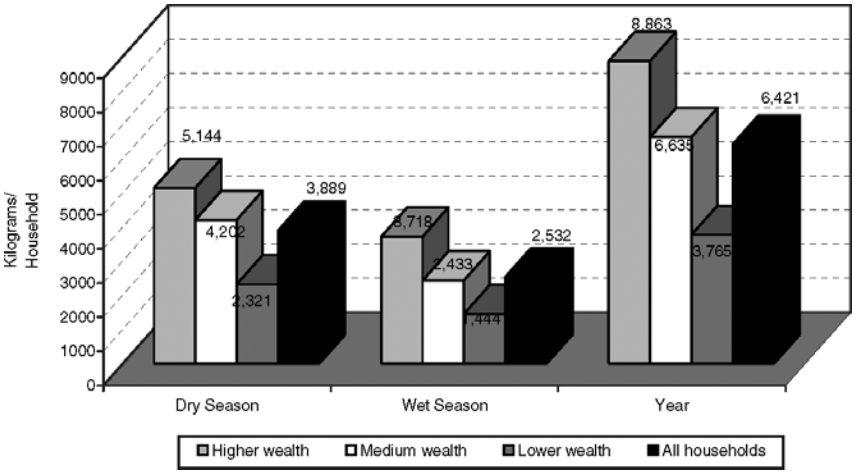
RESULTS AND DISCUSSION

Quantities of Fish Catch, and Aquatic Plants and Animals Gathered

In the discussion in this section, quantities of fish catch, and aquatic plants and animals gathered represented the average for all fish, plant, and animal species caught and gathered. No effort was done to analyze by individual species because of the numerous species and the obvious immensity of work involved. Instead the economic approach of taking average values was considered sufficient for the purpose.

The average fish catch by households by wealth type in the covered villages in Siem Reap, seasonally and annually, is presented in Figure 2. Between household wealth types, catch was highest among higher-wealth households followed by medium-wealth and lower-wealth households in the dry and wet seasons, and annually. For all household wealth types, catch was higher in the dry season than in the wet season. Average annual catch was about 8.9 tons, 6.6 tons, and 3.8 tons per household for higher-wealth, medium-wealth, and lower-wealth households, respectively. The

FIGURE 2. Seasonal and annual total fish catch by households in 3 villages in Siem Reap, Cambodia.



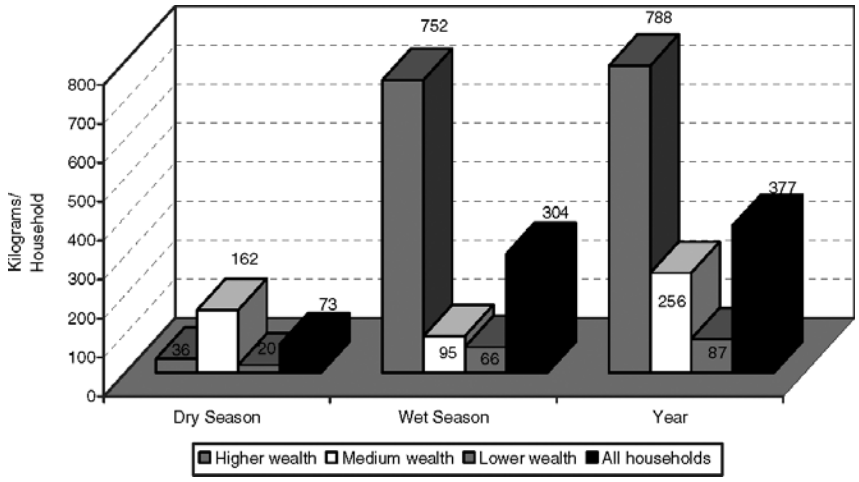
Note: November 2003-October 2004.

average annual catch for all households regardless of wealth type was about 6.4 tons.

The average aquatic plants gathered by households seasonally and annually in Siem Reap were presented in Figure 3. Between household wealth types, gathering was highest among higher-wealth households during the wet season and among medium-wealth households in the dry season. For all households regardless of wealth type, gathering was higher in the wet season than in the dry season. Average annual gathering was 788 kg, 256 kg, and 87 kg per household for higher-wealth, medium-wealth, and lower-wealth households, respectively. The average annual gathering for all households regardless of wealth type was 377 kg.

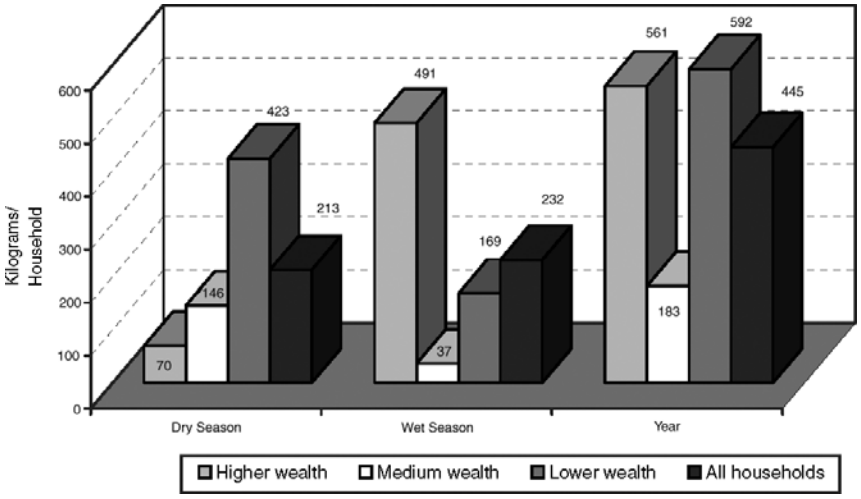
The average aquatic animals gathered by households seasonally and annually in Siem Reap were presented in Figure 4. Between household wealth types, gathering was highest among higher-wealth households during the wet season and among lower-wealth households in the dry season. For all households regardless of wealth type, gathering was higher in the wet season than in the dry season but the difference appeared small. Average annual gathering was 561 kg, 183 kg, and 592 kg per household for higher-wealth, medium-wealth and lower-wealth households, respectively. The annual gathering for all households regardless of wealth type was 445 kg.

FIGURE 3. Seasonal and annual aquatic plants gathered by households in 3 villages in Siem Reap, Cambodia.



Note: November 2003-October 2004.

FIGURE 4. Seasonal and annual aquatic animals gathered by households in 3 villages in Siem Reap Province.



Note: November 2003-October 2004

To summarize, average fish catch per household was significantly higher among higher-wealth households than among medium-wealth and lower-wealth households. Across household wealth types, fish catch was higher in the dry season than in the wet season. In general, the gathering of aquatic plants and animals was higher in the wet season than in the dry season. Between household wealth types, the gathering of aquatic plants was higher among higher-wealth households than other households. Lower-wealth and higher-wealth households gathered more aquatic animals that medium-wealth households.

Economic Valuation of Aquatic Resources

This section presented the results of the economic valuation conducted. The following should be noted before proceeding further. Cost and returns data (Table 4) were averages per household. The cost and returns figures were presented in riels to give an accurate picture of the monetary values involved in local terms. Following the theoretical discussion of the NEV earlier, total returns were computed as quantity of output, for example, fish, multiplied by the price of the output. Total costs included production costs (quantity of the input multiplied by the price of the production input) such as labor, gasoline, bait, plus the fixed costs including depreciation and other costs. Depreciation was computed as purchase price of the fixed asset less salvage value divided by economic life. Detailed calculations done to generate the depreciation figures presented in the table were provided in Israel et al. (2005b). Other costs referred to repairs and maintenance, the cost of borrowing money, and miscellaneous costs (which were estimated as 10 percent of production costs plus depreciation). Net income data were calculated excluding (or not subtracting) and including (or subtracting) labor costs. Labor used for the activities was generally household labor and not hired labor. Labor costs were computed at the rate of 5,000 riels per person-day of 8 hours to reflect its true market value. The price of labor was constant across activities and seasons based on PRA information.

Fishing was classified as motorized and non-motorized. Motorized fishing used bigger and motorized boats as well as relatively more sophisticated fishing gears and techniques. Relatively wealthier households conducted motorized fishing in Siem Reap province. Non-motorized fishing, on the other hand, used smaller and non-motorized boats as well as relatively simpler fishing gears and techniques. Poorer households usually practiced it in the province. Of the household activities

TABLE 4. Seasonal costs and returns of different aquatic resources-based household livelihood activities in Siem Reap, 2004 (riels/household).

Item	Wet	Dry
A. Motorized fishing		
Total returns	7,074,800	9,346,000
Costs		
Labor	1,520,000	1,520,000
Gasoline	583,200	583,200
Bait	81,000	81,000
Depreciation	265,000	265,000
Other costs	244,920	244,920
Total costs	2,694,120	2,694,120
Net income (incl. labor costs)	4,380,680	6,651,880
Net income (excl. labor costs)	5,900,680	8,171,880
B. Non-motorized fishing		
Total returns	4,459,700	6,524,000
Costs		
Labor	1,215,000	1,215,000
Bait	0	0
Depreciation	232,000	232,000
Other costs	144,700	144,700
Total costs	1,591,700	1,591,700
Net income (incl. labor costs)	2,868,000	4,932,300
Net income (excl. labor costs)	4,083,000	6,147,300
C. Fish culture		
Total returns		2,400,000
Costs		
Labor		455,000
Fingerlings		450,000
Feeds		547,500
Depreciation		342,500
Other costs		179,500

TABLE 4 (continued)

Item	Wet	Dry
Total costs		1,974,500
Net income (incl. labor costs)		425,500
Net income (excl. labor costs)		880,500
D. Fish processing		
Total returns	122,500	429,000
Costs		
Labor	12,500	50,000
Mixed fish	74,000	234,400
Salt	16,000	65,000
Depreciation	5,800	5,800
Other costs	12,310	41,380
Total costs	120,610	396,580
Net income (incl. labor costs)	1,890	32,420
Net income (excl. labor costs)	14,390	82,420
E. Gathering of aquatic plants		
Total returns	304,000	73,000
Costs		
Labor	40,000	15,000
Depreciation	2,125	2,125
Other costs	4,213	1,713
Total costs	46,338	18,838
Net income (incl. labor costs)	257,662	54,162
Net income (excl. labor costs)	297,662	69,162
F. Gathering of aquatic animals		
Total returns	348,000	319,500
Costs		
Labor	300,000	250,000
Depreciation	2,125	2,125
Other costs	30,213	25,213
Total costs	332,338	277,338

Item	Wet	Dry
Net income (incl. labor costs)	15,662	42,162
Net income (excl. labor costs)	315,662	292,162
G. Gathering of aquatic wood		
Total returns	189,000	
Costs		
Labor	70,000	
Depreciation	21,750	
Other costs	9,175	
Total costs	100,925	
Net income (incl. labor costs)	88,075	
Net income (excl. labor costs)	158,075	
H. Provision of public water transportation		
Total returns	10,000,000	3,000,000
Costs		
Labor	750,000	600,000
Gasoline	2,400,000	0
Depreciation	600,000	40,000
Other costs	375,000	64,000
Total costs	4,125,000	704,000
Net income (incl. labor costs)	5,875,000	2,296,000
Net income (excl. labor costs)	6,625,000	2,896,000

considered, gathering of aquatic wood was assessed only for the wet season. (Households actually cut the trees illegally, hide them in the bushes in the dry season and then collect them as drift wood in the wet season.) Similarly, fish culture was assessed only in the dry season at time of harvest but entire culture actually took 12 months.

Based on the results presented in Table 4, the following were the important findings of the economic valuation of aquatic resources used in household livelihood activities:

1. Livelihood activities using aquatic resources earned positive net incomes per household even when labor was taken as part of the

costs. This finding suggested that these activities were not just for subsistence but also for income generation.
2. Except in fish processing, labor formed a significant part of the costs of the livelihood activities implying that the activities were labor intensive and an important source of employment for households.
3. Net incomes per household were relatively high in motorized fishing, non-motorized fishing, fish culture, and provision of public water transportation. The households may have conducted these activities mainly for income generation.
4. Although net incomes from motorized fishing done by wealthier households were higher (due to higher catch) than non-motorized fishing done by poorer households, both earned high positive net incomes and had significant labor costs. This implied that fishing contributed to income and employment among households of all wealth types in the villages.
5. Net incomes per household were relatively low in fish processing and the gathering of aquatic plants and animals. Households may have conducted these activities for domestic purposes as much as for income generation.
6. Net incomes from the gathering of aquatic wood were positive and relatively high. This may help explain the continued practice of this illegal activity in Siem Reap. In particular, households may have gathered aquatic wood not only for domestic use but also for income generation.
7. In addition to labor, fingerling and feeds were important cost items in fish culture. Thus, fish culture among households was relatively capital intensive and dependent on linkages to the fingerling and feeds suppliers.
8. The provision of public water transportation was a lucrative livelihood activity for the households. Therefore, the water itself and not just the living aquatic resources in it were used by households for income generation.
9. For motorized fishing, non-motorized fishing, and fish processing, net incomes were higher in the dry season than in the wet season. In contrast, net incomes were higher in the wet seasons for the gathering of aquatic plants and animals and provision of public water transportation. Therefore, seasonality also played an important role in the economic use of aquatic resources.

The average annual values of the aquatic resources-based activities in a typical village in Siem Reap are presented in Table 5. The values

TABLE 5. Annual values of aquatic resources for an average aquatic resources dependent village in Siem Reap, 2004 (million riels).

Economic activity	Gross value	Net income (incl. labor costs)	Net income (excl. labor costs)
Motorized fishing	886.7	595.8	759.9
Non-motorized fishing	1,482.8	1,053.0	1,381.1
Fish culture	103.2	18.3	37.9
Fish processing	44.7	3.4	8.4
Gathering of aquatic plants	77.3	63.9	75.2
Gathering of aquatic animals	136.8	11.9	124.6
Gathering of aquatic wood	41.4	19.3	34.6
Water transportation	26.0	16.3	19.0
Total value of aquatic resources (million riels)	2,798.9	1,781.9	2,440.7
Total value of aquatic resources (thousand US$)	699.7	445.5	610.2

were computed by multiplying the economic values per activity and per household presented in Table 4 by the estimated number of households involved in a typical village (see Israel et al., 2005b). It should be noted that although fish culture and the provision of water transportation had high net incomes per household, the contributions per village were small because few villagers actually conducted these activities. In contrast, although the net incomes per household were low for the gathering of aquatic plants and animals, the contributions per village were high because many villagers practiced these activities. Based on the computation, the NEV of aquatic resources with labor costs included in the computation of costs in all the activities per village was 1,781.9 million riels or US$445,500. The computations further showed that, whether it was taken as part of costs, labor significantly affected the NEV value indicating its great importance in the economic use of aquatic resources among households.

In summary, based on these economic valuation results, it was shown that aquatic resources contributed positively to household income and employment and were important to households not just in fishing but also in other extractive and non-extractive livelihood activities.

Constraints to Access to Aquatic Resources

The constraints to access of aquatic resources identified by villagers in Siem Reap were the payment of access fees and the existence of fishing lots, fish sanctuaries, and closed seasons. The importance of these issues among different household wealth types was considered (Table 6). The following were the important findings:

1. More of higher-wealth households than medium-wealth households and lower-wealth households said that the payment of access fees was an issue in their village, actually paid for these, and believed that access fees reduced their access to aquatic resources. While a majority of higher-wealth households said payment of access fees existed in their village, only a minority (33 percent) believed that the fees reduced their access to resources.
2. A majority of households of all wealth types said that the presence of fishing lots was an issue in their village. Also a majority of all wealth types thought that fishing lots limited their access to aquatic resources. More medium-wealth households than higher-wealth and lower-wealth households believed that fishing lots limited their access to resources.
3. A majority of households of all wealth types said that the presence of fish sanctuaries was an issue in their village but only a few thought that fish sanctuaries limited their access to aquatic resources. More of higher wealth households than medium wealth and lower wealth households believed that fish sanctuaries were an issue in their village.
4. A majority of households of all wealth types said that the imposition of closed season was an issue in their village although only a few of higher wealth households and none of medium and lower wealth households thought that it limited their access to aquatic resources. More of higher wealth households than medium wealth and lower wealth households said that the imposition of closed season was an issue in their village.

In summary, of the four access issues identified by villagers the presence of fishing lots was the one considered by most households as significantly limiting their access to aquatic resources. The payment of access fess was an issue but was considered as constraining resource

TABLE 6. Access issues faced by households in villages covered in Siem Reap, 2004.

Access issues	Higher wealth	Medium wealth	Lower wealth
Payment of access fees (% of households)			
Issue exits	60	49	27
Households that pay access fees	51	40	20
Effect of the issue on households			
Reduces access	33	27	13
Increases access	2	2	2
Remains the same	25	22	12
No opinion	40	49	73
Presence of fishing lots (% of households)			
Issue exits	78	77	75
Effect of the issue on households			
Reduces access	62	65	62
Increases access	0	3	0
Remains the same	17	10	12
No opinion	21	22	26
Presence of fish sanctuaries (% of households)			
Issue exits	63	58	55
Effect of the issue on households			
Reduces access	3	2	2
Increases access	10	3	5
Remains the same	50	53	48
No opinion	37	42	45
Imposition of closed season (% of households)			
Issue exits	97	92	88
Effect of the issue on households			
Reduces access	2	0	0
Increases access	0	5	0
Remains the same	95	87	88
No opinion	3	8	12

access by only a minority of households. Few households thought fish sanctuaries and closed seasons reduced access to aquatic resources in their villages.

CONCLUSIONS AND RECOMMENDATIONS

In general, the economic valuation done in this paper found that aquatic resources in both extractive and non-extractive use had substantial value in terms of income, employment and livelihoods to households in the rural villages of Siem Reap. This finding suggested the need for the proper use and management of these resources for their continued use by households.

Since aquatic resources-based livelihoods provide incomes and employment to rural households, they should be promoted by the government for economic development in the aquatic resources-dependent rural areas of Siem Reap, with due consideration to the resource and environmental concerns that accompany economic intensification. In recent years, stakeholder-based community fisheries management has gained ground in theses areas with the implementation of the sub-decree on community fisheries and the establishment of community fisheries committees at the commune and village levels. Supporting this innovative approach of management may not only lead to a balanced rural development with both economic and environmental concerns considered but also allow the full participation of the rural population in the management of local aquatic resources.

The findings indicated that in general, aquatic resources-based activities in the villages of Siem Reap may not be for subsistence alone but also for income generation. Thus, it is worthwhile to consider not just fishing, as what is currently done, but other livelihood activities (excluding the gathering of aquatic wood), for future planning and development.

Special mention may be afforded to fish culture that was found to be relatively profitable in this analysis. The activity has been practiced in some villages of Siem Reap but only in a limited way. Fish culture development may be seriously considered for the province but with due considerations to its potential negative environmental effects and the available resource base.

The gathering of wood by households from the flooded forests of Siem Reap has been a controversial issue and more so that it was found to be an economically lucrative activity way beyond subsistence.

That it remains to be practiced by households is an indication of poor monitoring and enforcement by the authorities, among others. This function of pertinent agencies has to be strengthened to save the last flooded forests of Siem Reap.

Other specific findings of the study have relevance to the development of the rural areas in Siem Reap as well. The results here showed that household wealth type and season had important bearings on fish production and the use of aquatic resources. Hence, future programs and activities for the development of aquatic resources to benefit the rural poor households in Siem Reap, such as micro-credit, may have to take account of differences in wealth and seasons to accurately target the intended beneficiaries. For instance, micro-credit programs may be aimed at lower wealth households specifically to promote the gathering of aquatic plants and animals as a livelihood activity in both dry and wet seasons.

The results further showed that the water itself, and not just the living resources in it, have important economic value to households, specifically in the provision of public transportation. Development programs can explore various other ways of using the water not just for transportation but for other economic activities such as animal raising. In particular, duck raising has been found to be beneficial to households in Takeo (Israel et al., 2005b) and can also be aggressively promoted in Siem Reap.

With fishing lots as the main access issue in the villages of Siem Reap, the fishery reforms that led to the reduction of fishing lots in Siem Reap and other provinces were a step in the right direction. However, more needs to be done as the fishery reforms may also have caused the shift to the intensification of open-access fisheries and the rapid destruction of aquatic resources in the country. The fishing lot system has to be studied to address the remaining problems.

Finally, the results of this economic valuation are limited to the marketable and direct uses of aquatic-based resources in Siem Reap. A broader understanding of the total economic value of these resources could be developed through expanding this research into non-market valuation to measure the indirect use values and non-use values of these resources.

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