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Abstract Cheung Ek Lake receives 80% of Phnom Penh's urban wastewater. Since most of the lakes around Phnom Penh are being reclaimed for urban development, surveys were undertaken to analyze the direct-use economic value of Cheung Ek lake in the dry season, which could serve for policy-makers' future considerations. The direct-use value was assessed by summing total income of all activities performed on the lake. Income was calculated using a bottom-up approach based on a stratified sampling and on in-depth interviews of 192 households using structured questionnaires for each household's activity. The primary activities are water spinach, water mimosa, and rice cultivation, fishing, and duck raising. Over a six-month period, farmer receive an average profit of 4,168 USD/ha from water mimosa cultivation, 1,553 USD/ha from water spinach cultivation, 512 USD from fishing, 506 USD/ha from dry season rice cultivation, and 157 USD/100 ducks from duck raising. After multiplication by the total area of plants (from remote sensing), and number of household and duck numbers (by direct investigation), the direct-use value was estimated at more than 1 million USD, of which water spinach production contributes 65%, fishing 20%, water mimosa production 13%, duck raising 1%, and dry season rice production 0.7%. The study suggests that almost a thousand of direct-beneficiaries can generate part of their income from agriculture or fishery-related activities performed on the lake. Moreover, the research targeted only one part of direct-use value of the lake and thus largely underestimated the overall value of the lake. Indirect-value components are community health (which can be greatly improved through water purification), and indirect-use value of the lake (e.g. tourism), both of which have major economic implications and which must be taken into account in further research.

Keywords direct-use value, Cheung Ek Lake, water spinach, Phnom Penh

INTRODUCTION

Wastewater use in agriculture and aquaculture has a long history in China (Zhiwen, 1999), Cambodia and Vietnam, to culture fish and aquatic plants in peri-urban wetlands (Kuong et al., 2005; Leschen et al., 2005; Lan et al., 2007). Phnom Penh, with a surface area of 375 km², is surrounded by wetland, of which 80% comprises natural lakes and low-plain agriculture. Every day, about 55,600 m³ of urban household wastewater and nearly 1 million m³ of storm water are discharged into these wetlands (Muong, 2004). This wastewater is used in numerous plots located within and around the wetlands in peri-urban Phnom Penh, and provides important sources of

edible aquatic vegetables and fish farming to supply the food demand of the city and other areas of Cambodia (Khuong et al., 2005). Cheung Ek Lake, a seasonally inundated lake located about 5 km to the south of Phnom Penh, is a large water body that receives 80% of the wastewater from Phnom Penh's urban population and from factories (garment and various other factories). Rainfall run-off also discharges into the lake (Seyha and Tuan Anh, 2004). Cheung Ek Lake is an important area for growing aquatic plants and fish production, and harvesting is undertaken throughout the year. The activities on the area of Cheung Ek Lake represent not just the most important source of the income of many households, but also the employment and income earning opportunities for many seasonally hired labourers engaged in setting up, maintaining and harvesting the plants (Balmissse and Sylvain, 2003), as well as low-cost wastewater treatment. In 2009, 429 hectares of water spinach, 32.1 hectares of water mimosa, and (during the dry season) 13.5 hectares of dry-season rice were cultivated within the Cheung Ek Lake boundary (Teang, 2009).

The purpose of this research is to understand the economic value of Cheng Ek Lake by identifying the primary human activities performed on the lake and assessing the direct use value of the lake from those activities that could assist policy-makers' future considerations.

METHODOLOGY

An inundated lake, Cheung Ek Lake, was the research site of this study. The sampling was primarily stratified by activity, as the human activity performed on the lake is very diverse. It was then stratified by village in order to obtain more reliable results, as farmers involved in each activity live in 15 different villages around the lake. 192 households from a total of 900 households working directly on the lake were randomly selected for in-depth interview using a structured questionnaire. The study was conducted from December 2008 to May 2009, which was a period of dry season. Direct observation and interviews with key informants were first used to better understand the diversified activities and the landscape of the area, followed by direct household interviews to obtain information on the household's income-generating activities performed on the lake. The direct-use value of the lake was assessed by summing up the total profit of all activities performed on the lake. The profit of each activity was calculated by the total income minus by the total expense. This excluded the labour costs of 2–3 producers per household in each activity; these producers were not paid salary, being all family workers.

RESULTS AND DISCUSSION

On Cheung Ek Lake, five main socio-economic activities are undertaken by the farmers who have migrated from other provinces throughout Cambodia. These five major activities are: water spinach cultivation (350 households), water mimosa cultivation (110 households), dry season rice cultivation (19 households), fishing (402 households) and duck raising (19 households). In 2009, a total of 900 households were working directly on the lake during the dry season.

Many of the respondents are not born in the districts, communities or villages where they currently reside; they are mostly migrants from other provinces throughout the country. They came from Kampong Chhnang, Kampong Thom, Kandal, Prey Veng, Svay Reang and Takeo provinces. As shown in Fig. 1, most of the water spinach and water mimosa cultivators and less than half of fishermen and dry season rice cultivator are migrants while all the duck raisers were born in this region. The study indicated that the migration from the provinces for water mimosa cultivation in Cheung Ek Lake started within the last five years, while for water spinach cultivation it started more than 20 years previously and has been increasing with time. The results from this research indicate similar reasons for the migration process to those found by Rigg and Salamanca (2006a). It is suggested that the major reasons that respondents gave for moving to peri-urban aquatic plants production region are: to find work, to follow or join their families, to move into a new economic zone, to pursue a work-related initiative, as well as due to war or marriage. Thus, it can be assumed that the movement of people to peri-urban regions are propelled primarily by work or livelihood

concerns. The migration rate has been steadily increasing over time, which leads to greater demand of land for agricultural activities, thus pushing the renting cost to increase significantly.

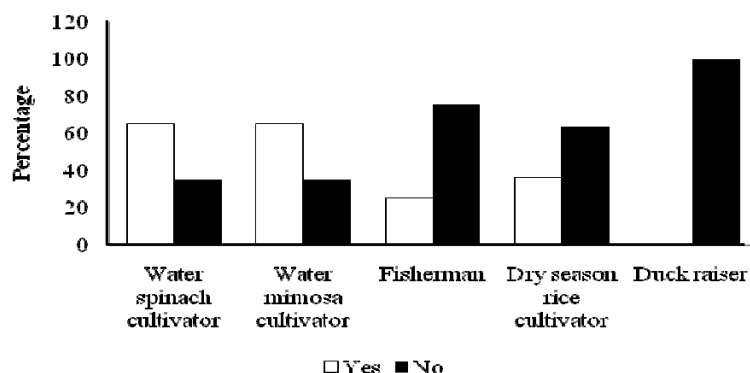


Fig. 1 Migration of farmers to Cheung Ek Lake

As most of the farmers working on the lake were migrants from other provinces throughout the country, they needed to rent the land on average 300-400 USD per hectare for their activities: as shown in Table 1, almost of the water spinach and water mimosa cultivators were renters, as were more than half of dry season rice cultivator and duck raisers. Some of the producers on the lake own the land for cultivation. In a very few cases, farmers were asked to look after the land by the landlord and were able to work on the land without paying rent. According to Rigg and Salamanca (2006b), the ownership of the land among surveyed households in Aquatic Food Plants Production Systems in both Bangkok and Ho Chi Minh City is high, but this is not the case for either Phnom Penh or Hanoi. Kuong et al. (2006) stated that, in Phnom Penh, about 10% of the households from two villages, Kbal Tumnub and Thnout Chrum, owned the land for water spinach cultivation. The present research has found similar results: most of the water mimosa and water spinach cultivators and the duck raisers in Cheung Ek Lake need to rent the water surface area from the landlord for their cultivation (95%, 92% and 63% respectively). In addition, only 53% among 19 households of dry season rice cultivators need to rent the land for dry season rice practice on the lake.

Table 1 Land ownership by activity

Activity	Rent (%)	Owned (%)	Other (%)
Water spinach cultivation	92.4	7.6	0.0
Water mimosa cultivation	95.0	5.0	0.0
Dry season rice	53.0	21.0	26.0
Duck raising	63.2	21.0	15.8

Generally, villagers can only own water surface area they inherited from their forebears. Few migrants own the water area they use for cultivation. Most farmers find difficulty in facing the high cost of water-surface area rental and the expense of chemicals. Thus, they need to borrow money in any way they can for their initial inputs. The cultivators usually borrow money from the middlemen and they pay the interest in the form of selling the product back at slightly lower than the market price, or they borrow from their neighbours at a high rate of interest (about 10%) and can sell their products at the market price. There are a limited number of farmers who borrow money from micro-credit banks or organizations, as most do not want to follow the institution's restrictions. It is very rare for the fishermen, rice cultivators, and duck raisers to borrow the money from their production as their initial input is not as high as water spinach and water mimosa production. Most of the farmers working on both aquatic plants cultivation and fish culture in the four main cities in Southeast Asia mentioned the need to take a loan for their initial costs of production, except in Ho Chi Minh City where most of the farmers could not take the credit from any sources of loan as they did not meet the loan terms set by the government. According to Yoonpundh et al. (2006), fewer aquatic plant cultivators took out loans for their cultivation (water spinach cultivator 27% and

water mimosa cultivator 10%). Nevertheless, the results from Kuong et al. (2006) found that many water spinach producers in Kbal Tumnob and Thnout Chrum villages in the Phnom Penh peri-urban region took out credit (60% and 40% respectively). The results from this research, as shown in Fig. 2, are similar to the previous results of Kuong et al. (2006), as 63% of the total households from 8 villages working on water spinach cultivation and 59% of water mimosa cultivators took loans from various sources for the initial input of production.

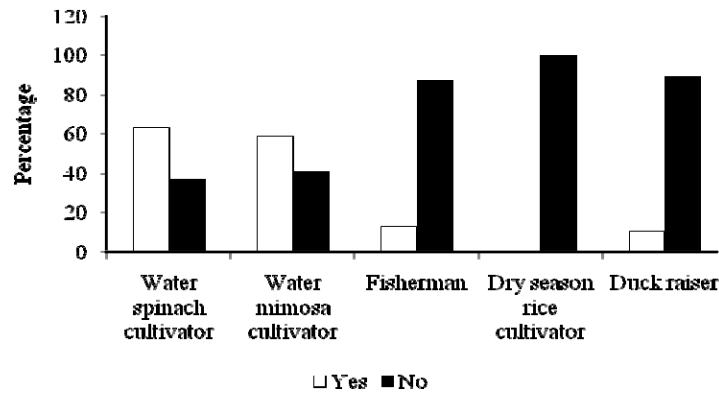


Fig. 2 Credit for inputs of production

The producer can either sell the product to the middlemen or sell it directly at the markets. The product is transported by middleman or producer to the wholesalers in the main markets in Phnom Penh. At these markets, the wholesalers sell the product to retailers from other markets in Phnom Penh and also to other traders from the provinces, such as Koh Kong, Sihanuk ville, and Kampong Cham. Finally, the product is sold to consumers for their daily household diet. The results from this study are similar to those of (Yoonpundh et al., 2006; Huy and Hung, 2006; Phuong et al., 2006; Kuong et al., 2006) regarding market processing. It seems that the marketing process for aquatic food production is quite similar throughout Southeast Asia. The transaction cost from producer to consumer is an average 900 riels per bunch for water spinach and 1,600 riels per kilogram for water mimosa. The prices of both water spinach and water mimosa are higher in the dry season than in the wet season. Fishermen sell their product to the local markets in the nearest accessible market whereas the main markets for the middlemen's supply are not identified yet. Duck eggs are sold by farmers to the middlemen, and then they are supplied to the local market and also transported to the main markets in Phnom Penh. The product from rice production is usually used for household consumption, although in some cases it is sold to neighbours in the villages.

The findings show that the household income varies with activity: water spinach cultivators obtained an average income of 1,431 USD, water mimosa cultivators 1,795 USD, fishermen 512 USD, dry season rice cultivators 359 USD, and duck raisers 537 USD per household per dry season. Yoonpundh et al. (2006) stated in the report of the Production in Aquatic Peri-Urban Systems in Southeast Asia (PAPUSSA) that the water spinach farmers in Bangkok received higher income (3,943 USD/HH/year) compared to water mimosa farmers (120 USD/ HH/year). This happened as the water mimosa was destroyed by contaminated water in the canal during the time of survey. These are similar results to those of Huy and Hung (2006). The results of the survey on peri-urban aquatic food production in Phnom Penh showed that income levels of households involved in water spinach production in the Cheung Ek lake area were mostly found to be within 200-500 USD/HH/year. Less than one third of these households ranked their annual income from water spinach production in the range of 500-1000 USD and only a few earned within 1000-5000 USD (Kuong et al., 2006). The average price received by the producer per bunch of water spinach was only 134 riels. The present research shows that water spinach cultivators in Cheung Ek Lake now receive improved benefits than in the previous 3 years, with an average profit of 1,431 per six months. The profit of water spinach cultivators may be increased as the average price per bunch of water spinach has increased to 550 riels, and most of the cultivators have increased the water

surface area for water spinach production. The difference of the results of current research and the results of Kuong et al. (2006) may happen because of the sampling methods. Koung et al. (2006) randomly selected the respondents from the two main villages involved in water spinach cultivation whilst in the present research, the respondents were selected from all the 15 villages where the farmers are involved in water spinach cultivation and the sampling is first stratified by activity performed on the lake and then by village.

The direct use value of Cheung Ek Lake is the sum of the total cash net income from each direct human activity during the period of the dry season. Table 2 shows that households received a total profit of 1,020,236 USD over the six months of the dry season: a substantial total. Within this, water spinach production gave the main contribution (65%), 666,237 USD with a total cultivation area of 429 ha whilst dry season rice production is the smallest contribution among the five (0.67%) with a total profit of 6,912 USD with a total area of 13.5 hectares.

Table 2 Direct use value of Cheung Ek Lake during the dry season

Activity	Average profit (USD)	Total area/household/head	Total profit (USD)
Water spinach	1,553 /ha	429 ha	666,237
Water mimosa	4,168 /ha	32.1 ha	133,793
Fishing	512 /HH	402 HHs	203,412
Dry season rice	506 /ha	13.5 ha	6,912
Duck raising	157 /100 heads	6,293 heads	9,882
Total			1,020,236

CONCLUSION

Cheung Ek Lake is a vital economic resource on the urban margin of Phnom Penh, providing at least more than a million USD per dry season to about a thousand direct beneficiaries. The agricultural activities provide a vital fresh food source for markets and help to assure food security in Phnom Penh as well as being distributed to other provinces throughout the country. This regional economy also involves growers, wholesalers, distributors and local customers, and provides a valuable trade network in essential commodities such as foodstuffs and animal fodder. Among the five types of farmers, water mimosa cultivators receive the highest household income (1,795 USD) whereas dry season rice cultivators obtain the lowest (359 USD). Within the substantial profit from the direct value of the lake, water spinach production gives the main contribution (65%) whilst dry season rice production is gives the least contribution among the five (0.67%). Given the significant value of the lake to the local people found in this research, policy-makers should make careful considerations before implementing future development plans on this lake region as it may affect seriously on many households' livelihoods and the food security in Phnom Penh.

The direct use value here is just a part of the overall economic value of the lake and it focuses only that from the direct beneficiaries of the human activities on the lake. The value from the indirect beneficiaries such as harvester, middlemen, wholesalers, and retailers should be explored and considered as a part of the direct use value of the lake, as well as the indirect impact of health and future tourism. This body of water also functions as a means of water purification, which is regarded as another component to the direct use value. Water purification and the indirect use value of the lake which are great importance for future economic potential must be taken into account to assess the overall economic value of the lake. Although agricultural activities provide a vital economic link to food markets, there is growing concern for the health implications of this practice. Waste, including heavy metals, organic pollutants, dissolved nutrients, and biologically active agents are entering the lake throughout the year, with dilution as the only mitigating factor. This wastewater constitutes a dangerous situation for the socio-economic importance of Cheung Ek Lake, as negative effects on human health and economic viability of agricultural practices begin to appear. The implications are two-fold: (i) for the individual - the high cost medical bills and (ii) for the community - mitigating problems of poor health and disease epidemics, compounded by a

workforce containing significant numbers of people too unwell to contribute to the economy. A simple wastewater treatment plant to reduce pathogens and contaminants entering the lake could overcome many of these problems. If coupled with policies on waste for industries, agriculture and urban communities will see a positive impact on the socio-economic health and wealth of this region. In addition, there is the indirect use of the lake region that could arise in the future from tourism if the lake is relatively unpolluted.

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