



## Spatial Analysis of Human Activities Performed in Cheung Ek Inundated Lake, Cambodia

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**Abstract** Cheung Ek is an important lake for the livelihood of local communities through different functions, it acts as a wetland area to control flood waters and removes pollutants from Phnom Penh city. However, industrialization, urbanization and uncontrolled human occupation on the bank of the lake has decreased the lake's surface and caused the lake to become incapable of the evacuation and retention of storm water under the conditions of heavy rain. Global Positioning System (GPS) mapping was undertaken to analyze the lake border, water spinach and water mimosa surfaces and other human activities while other surveys were conducted to understand the method of cultivation and yield estimation of the main aquatic vegetables. The surface area of Cheung Ek Lake in the dry season is 992 ha and more than 50% of the area is occupied by human activities: 429 ha of water spinach; 32 ha of water mimosa; 13.5 ha of dry season rice field; 10-20 ha of fishing activities and around 10 ha of duck raising. In Cheung Ek Lake, water spinach and water mimosa are grown in rows secured by strings between the poles to prevent the crop from floating away. During the dry season, a water spinach cultivator can obtain an average yield of 16-17 tons/ha for a six-month production cycle while a water mimosa producer obtains an average of 15.5-16 tons from a production area of 5000 m<sup>2</sup> during a five month production cycle. In conclusion, during the dry season, the lake provides from 6864-7293 tons of water spinach and 992-1024 tons of water mimosa for human consumption. However, aquatic vegetable production is also facing many problems particularly with insect damage and disease outbreaks during the production period.

**Keywords** spatial analysis, GPS, aquatic vegetable, inundated lake, Cambodia

### INTRODUCTION

The majority of untreated wastewater from the major cities in Asia is discharged into peri-urban wetlands that serve as sites for natural treatment and extensive aquatic vegetable cultivation (Marcussen et al., 2004). The cultivation of aquatic vegetables in the peri-urban wetlands is widespread throughout many cities in South and Southeast Asia and is found to a lesser extent in Africa, Europe, Latin and North America (Bunting et al., 2005). Similar to many cities in Southeast Asia, peri-urban areas of Phnom Penh are very important for food production and supply (Dalsgaard et al., 2004). The use of humid zones as a lagooning system to purify urban waste is wide spread around the world and a lot of literature is available on this topic. In Southeast Asia, lagoons are used and have been studied in Vietnam, Thailand and Cambodia (Lim and Chhouk, 2008). In Phnom Penh, Cheung Ek Lake is a large body of water that receives a major part of the wastewater from Phnom Penh's population and from industrial activities. The lake also receives rain-water run-off (Seyha and Tuan Anh, 2004). The people living around the lake mostly produce several types of aquatic vegetable, particularly morning glory which contributes to the purification of urban waste water. In Phnom Penh, aquatic vegetable production systems in peri-urban areas, especially in Cheung Ek Lake, provide many benefits, not just income for producers and low cost

waste water treatment, but also the employment and income generation opportunities for many seasonally hired labourers. However, uncontrolled human occupation on the lake's bank has decreased the surface area of the lake without any compensation from year to year. Moreover, rapid urbanization and industrialization can be seen as the main future threat for the continued production of aquatic vegetables in this peri-urban waste water fed lake. Thus, the mapping of the lake's surface, the area occupied by water spinach fields and other human activities, are necessary for understanding the problems. The purpose of this paper is to describe and make reference to the human activities on the lake with particular reference to the farming of aquatic vegetable used for human consumption. This paper consists of two specific objectives: (i) to map the Cheung Ek lake border, water spinach area and other human activities in the dry season and (ii) to understand the life cycles of the aquatic vegetables (methods of cultivation and yield estimation).

## METHODOGY

### Site selection

The research was conducted at Chueng Ek lake which borders with the districts of Mean Chey, Dang kor and Takmao in the South of Phnom Penh city and about 5 kilometers from the centre of the city.

**Table 1 Sample size selection**

Village	Number of households	Aquatic vegetable producers	Sample size
Prek Takong 1	341	175	25
Prek Takong 2	309	21	4
Prek Tanou	416	10	2
Thnoat Chhrum	569	11	3
Thnoat Chhrum 3	296	10	3
Kvar	749	48	10
Cheung Ek	424	75	30
Total	3077	350	77

### Data collection

**Secondary data collection:** Existing relevant documents were collected from research institutions, journals and information obtained from personal contact with scholars and researchers who had carried out studies in the project area to better understand the issues involved. A satellite image of Cheung Ek Lake was also obtained which was used to determine changes in the lake border and human activities compared with aerial photos taken in 2008.

**Primary data collection:** Two steps were used in primary data collection. Firstly the area of aquatic vegetable cultivation, lake border and other human activities were mapped using GPS. Secondly was an interview with key informants and farmers. A semi-structured questionnaire (a) was used for key informant interviews and a structured-questionnaire (b) was designed for a household survey which focused mainly on cultivation techniques for aquatic plants (setting-up, maintenance and harvesting).

## RESULTS AND DISCUSSION

### Human activities in the lake

Activities within Cheung Ek Lake represented an important source of household income for many households in the Phnom Penh peri-urban area. Floating vegetable production particularly water

spinach and water mimosa, rice cultivation, fishing activities and duck raising contribute to the dynamic economic activities in the Cheung Ek area.

**Table 2 Area occupied by human activities at Cheung Ek Lake in the dry season**

Human Activities	Total area (ha)	Percentage (%)
Water spinach area	429	43.2
Water mimosa area	32	3.2
Dry season rice field	13.5	1.5
Fishing activity	15	1.5
Duck raising	10	1
Other aquatic plant and water surface	492.5	49.6
Total lake surface	992	100

### Fishing activity

Cheung Ek Lake is in general not used for fish production. However, fishing of wild fish species is done by men from the nearby households. A diverse range of fish *species* is caught such as common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), tilapia (*Oreochromis niloticus*), Snakehead fish (*Channa striata*) and Walking catfish (*Clarias batrachus*). The fish are sold at local markets or used as a supplement in the house diet.

### Dry season rice cultivation

The people living around the Cheung Ek Lake started growing paddy rice after they returned to their village after the Pol Pot regime (1975-1979). However, by the late 1980s many families had abandoned rice farming in order to cultivate aquatic vegetables, particularly water spinach, when they could see greater market demand and higher prices for aquatic plants. Currently rice farming in the Cheung Ek lake area is only practiced in the dry season by a small number of households in the western part of the lake particularly in Kvar and Cheung Ek village for use as a daily food supply and sold in emergency cases. The area of dry season rice cultivated in the Cheung Ek area is only 13.5 ha with a high yield of 2.5 - 3 tons per hectare.

### Duck raising

Duck raising is popular within the lake surface area especially in the western part mainly in Cheung Ek village. There are around 20 households in Cheung Ek village who raise ducks on both small and large scale from 100 ducks to 1,000 ducks. The KORKY variety is most popular because it is a good egg producer, resistant to disease and adapted to the climate conditions. Duck raising helps people to improve their living standard by earning profits from sale of eggs and can be sold for meat after two years of egg production. Moreover, this animal and their eggs can be used for daily food consumption.

### Water spinach (WS) production

Water spinach is the most common species grown in Cheung Ek Lake in terms of aquatic vegetable production. It is grown in rows secured by strings between two poles to prevent the crop from floating away. Water spinach or water morning glory (*Ipomoea aquatica*) is also planted on land and watered from ponds near the village with motor pumps and hoses. These plants are raised as seedlings and planted in the lake as the water level rises. Large water surface areas around 429 ha in the north and northwest part of Cheung Ek Lake are overgrown with water spinach, covering 43% of the total lake surface in the dry season.

### Water mimosa (WM) production

Water mimosa (*Neptunia oleracea*) is the second aquatic vegetable which is grown in Cheung Ek Lake. Similarly to water spinach, it is grown in rows secured by a string between two poles to prevent the crop from floating away. Because of higher input requirements and greater technical demands compared to water spinach cultivation, water mimosa is only planted by a small number of households in the western part and northeastern part of the lake particularly in Cheung Ek and Prek tanou village. It occupies a small area of water surface covering 32 hectares equal to 3.2% of the lake surface.

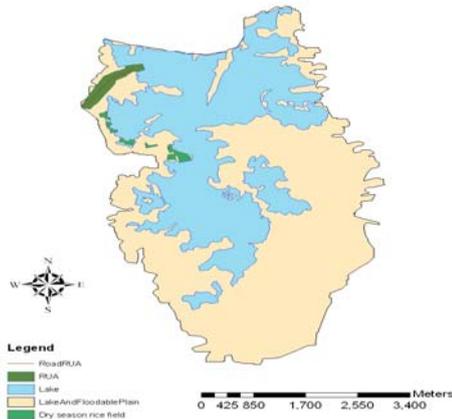


Fig. 1 Map of Dry season rice field in the Lake

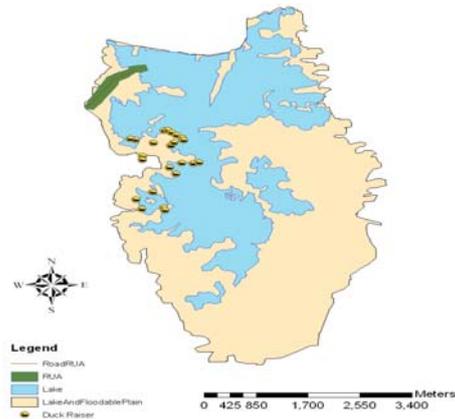


Fig. 2 Main area of duck raising

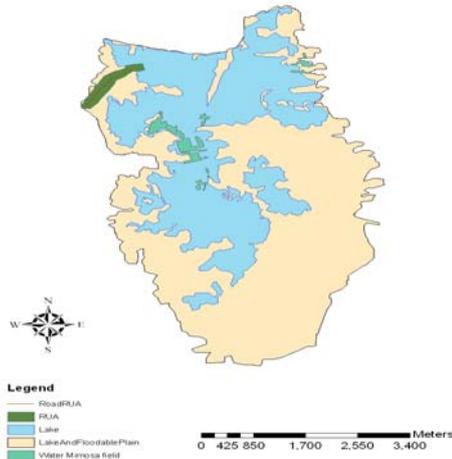


Fig 3 Map of WM surface in the Lake

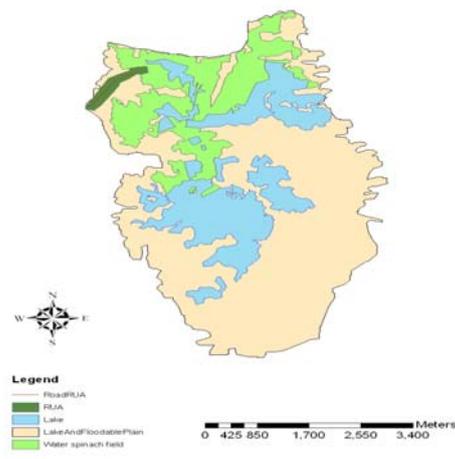


Fig. 4 Map of WS in the Lake

### Aquatic plant cultivation methods

#### Setting up

**Seed Propagation:** Water spinach or water mimosa stems are folded into a small piece and buried into a hole in the soil of depth 20 cm width and 10cm depth, with two sides of the stems exposed to the air. The seedlings should be planted in rows with 30 - 50 cm between each seedling.

**Taking care of aquatic plant seed:** Aquatic plants are regularly taken care by removing weeds and applying pesticides in order to allow them to grow well. One week after planting the seedlings should start growing and the farmers usually apply fertilizer and pesticide at this point. In the dry season, in the absence of rain, the farmers need to irrigate the aquatic plants with water from the

lake every 2 or 3 days. The seedlings can then be transferred to grow in floating rafts in the lake after 3-4 weeks of propagation on land.

**Transferring water spinach seedlings to the water:** Aquatic plants in water need to be in a raft floating on the surface, the propagated seed are bound with string tied up to poles which are already in place in the lake.

**Pole preparation:** Poles are set up in a rectangular design of 20 to 30 meters long, depending on the length of water surface owned by the farmer, and the rows of poles should be 3 to 4 meters apart. Floating ropes are then attached to the poles.

**Water spinach Seedling braiding:** Water spinach seedlings are folded as a forearm-size plant and braided with string, with 10 to 15 cm between each plant on the string. Whereas water mimosa should be selected 3 to 5 meters long with a big trunk and many stems twisted around by big white floating sponges. Two selected seedling plants are put together facing opposite directions and braided with string with 20 to 30 cm between each knots.

## **Maintenance**

**Taking care of aquatic plants:** In order to make aquatic plants grow well, the farmer needs to regularly keep the floating aquatic plants bed/raft clean by removing water hyacinth and water lettuce. A suitable amount of duckweed needs to be kept to cover the open water surface but kept from growing too thickly around the water mimosa. Weeds such as water hyacinth need to be removed. Snails need to be removed as they prey on aquatic plants. The strings, ropes and poles need to be maintained and the plants need to be irrigated with lake water to prevent leaves from wilting during the dry season and especially when new buds are emerging. Pesticide and fertilizer should also be applied as required.

**Fertilization:** Fertilizer and pesticide should be applied 5-7 days after plants have been transferred to the water. By this time, most leaves have fallen off and the new buds begin to develop at the base of the plant. To make the crop grow well and resist attack from diseases and insects, the farmer usually mixes many kinds of chemicals and pesticides together in one container and sprays once. However, this is not recommended. After applying chemicals, fertilizers and pesticides, aquatic plants are left at least one week before harvesting.

## **Harvesting and yield**

**Harvesting:** Water spinach can be partially harvested for the first time after 3 to 4 weeks while water mimosa can reach the first harvest after 2 to 3 weeks following planting. During harvesting, farmers have to tidy up their water spinach by arranging stems into a well disciplined format, as this allows the plants to continue to grow well and avoid blocking access for boats between the rows. Farmers always use a knife or sickle to cut the stems of water mimosa from both sides of the middle knots, and leave a 20 cm interval from knots on the stems in order to let the plant grow for later harvest.

**Yield:** In the dry season, the gross yield of water spinach is estimated to be 16 to 17 tons/ha. The yield is higher than previous estimates of 12 tons/ha/year reported by Khov et al. (2005) who conducted a survey among 133 water spinach producers in Cheung Ek Lake and 15.5 tons/ha/year observed by Huy and Moustier (2005) in a survey among 400 water spinach producers. However, these yields are very low compared to the yield of 73 tons/ha/year observed by Muong (2004) in a survey carried out among 205 producers in Cheung Ek Lake. Moreover, the finding (16-17tonnes/ha in the dry season) is also very low compared to the water spinach yield using similar cultivation techniques in other cities in South East Asia.

Phuong et al. (2006) conducted a survey among 63 households producing water spinach with wastewater use in Tran Phu and Bang B villages. They showed that the average yields of water spinach were 119 and 172 tons/ha/year respectively. Another study conducted by Ruangvit et al. (2002) on the water spinach production in and around Bangkok showed that, the gross yield is estimated at around 50.0 - 62.5 tons/ha/year for a total growing period of 95 to 105 days. On the

other hand the research also found that the gross yield of water mimosa was estimated to be 15.5 to 16.0 tons from a production area of 5000 m<sup>2</sup> during a production period of five months in the dry season. Unfortunately, there is no available information about the yield of water mimosa production in Cambodia from previous years. However the yields recorded in this study were very low compared to 37.50 - 46.87 tons per hectare throughout the whole cropping period of 75 - 90 days or 112.5 - 140.6 ton/ha/year reported by Ruangvit et al. (2002) for water mimosa cultivation in and around Bangkok.

**Table 3 Cropping calendar of aquatic plants (AP) in Cheung Ek Lake**

Month and activities	01	02	03	04	05	06	07	08	09	10	11	12
Seed cultivation											•	
Taking care												————
Fertilization												• •
Pole design												•
Seed braiding												•
Seed transfer to the water	•											
Fertilization	• •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• •
Taking care	————	————	————	————	————	————	————	————	————	————	————	————
Harvesting	•	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •

## CONCLUSION

Cheung Ek is an important lake for local resident’s livelihood as most of them practice some activities such as aquatic plant cultivation, rice cultivation, fishing and duck raising. However, rapid urbanization has caused people to move into the peri-urban area of Phnom Penh and this has decreased the lake surface from year to year. The lake surface of 992 hectare is occupied by 429 hectares of water spinach, 32 hectares of water mimosa, 13.5 hectares of dry season rice field, 15 hectares of fishing activities and around 10 hectares of duck raising. Farmers can obtain an average yield of 1105 kg/ha/harvest or 16 to 17 tons/ha of water spinach while water mimosa producers can obtain an average yield of 1217 kg/5000 m<sup>2</sup>/harvest or 15.5 to 16 tons/5000 m<sup>2</sup> during the dry season. The results show that, within a similar area of water surface, mimosa producers produce double the yield of water spinach. During the dry season, the lake can provide around 7584.7 tones of water spinach and 1012.5 tones of water mimosa for human consumption. However, aquatic plant production is faced with many problems included lack of labor for harvesting, decreased production due to the increase of water pollution, insect damage and disease outbreaks during the production period. Moreover, land use change is occurring on some parts of the lake which are being reclaimed for development purposes. This is causing concern to aquatic plant producers in the Cheung Ek area.

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