Traditional use and availability of aquatic biodiversity in rice-based ecosystems

I. Kampong Thom Province, Kingdom of Cambodia[1]

by

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INTRODUCTION

Food production in Kampong Thom Province is dominated by rice production and inland fisheries, both of which are heavily influenced by the Great Lake, also known as the Tonle Sap. Both systems contain a wealth of biological diversity that contributes to ecosystem processes, food security and cultural heritage.

THE GREAT LAKE ECOSYSTEM

The Tonle Sap, also known as the Great Lake in central Cambodia, is the heart of Cambodia's freshwater fisheries[2]. It is the largest freshwater lake in Southeast Asia and one of the richest inland fishing grounds in the world, with an estimated annual catch of 250 000 tonnes (Van Zalinge, personal communication). Its hydrological characteristics are mainly influenced by the Mekong River which, via the Tonle Sap River, fills the lake during the rainy season (May – October) and drains it for the rest of the year. The Tonle Sap basin contributes only 6.4% of the annual flood waters[3] (MRC 1998). In the dry season, the lake covers an area of 2 500 – 3 000 km^2 with an average depth of between one and a half and two meters. During the rainy season the area increases to 9 000 – 14 000 km^2 and the depth reaches 9 – 11 meters.

A belt of freshwater mangroves known as the "flooded forest" surrounds the lake. This gradually changes to bushes and finally grassland with increasing distance from the lake. The floodplains are surrounded by low hills, which are naturally covered with evergreen or deciduous dry Dipterocarp forest. The figures below show transects from the lake to the surrounding hills at the end of the wet and the dry season respectively.

Figure 1. Floodplain of the Tonle Sap in Kampong Thom during (a) October/November and (b) May/June

The lake's flooded forest and the surrounding floodplain are of great importance for Cambodia's freshwater fisheries. At the beginning of the flooding, many fish species leave the lake and the larger ponds for the now flooded forest to spawn. The young fish then move out into the floodplains to feed. The inflow of Mekong River floodwater brings with it large amounts of fry

[2] The coastal fisheries are relatively minor in Cambodia, in contrast to Viet Nam, Thailand, Philippines and Indonesia.

[3] It should be noted though that Tonle Sap River, which drains Tonle Sap Lake in the dry season, contributes 16% of Mekong River's flow in the dry season.

and fingerling which also finds shelter and food in the flooded forest and surrounding flood plains. At the end of the flooding, many fish follow the receding waters back to the lake and through the Tonle Sap River to the Mekong River.

RICEFIELD FISHERIES IN CAMBODIA

Traditionally the people living around the lake in areas subject to deep flooding were planting rice varieties that could cope with the high water levels by elongating their stems up to five meters with a maximum growth of ten centimeters per day. This floating rice was broadcast at the start of the rainy season on previously ploughed fields in areas naturally covered with bushes or grass. At greater distance from the lake where the flooding is not as deep, normal wet rice varieties are transplanted into the fields once the flood has reached them.

In some areas rice is planted in the receding water as the floodwaters recede. The water present in the soil has to be enough for the development of what is known as “receding” (recession) rice. With the introduction of improved rice varieties maturing quickly many areas formerly planted with deep water rice are now growing a recession rice crop instead. Controlled irrigation, which in Cambodia was present during the Angkorian period of the 13th Century, is nowadays the exception.

Rice is the staple of rural Cambodia and Ovesen *et al.* (1996) identified the deep cultural significance of eating (white) rice, going as far as being one of the things that separates humans from wild animals[4]. Fish and fishing is also central to rural households. In Cambodia there is a saying, "where there is water there is fish" (*mien tuk mien trey*) and considering that over a third of Cambodia is a seasonally inundated flood plain the significance is obvious. The importance of ricefield fisheries[5] is, however, generally underestimated. The Department of Fisheries (DoF) has traditionally concentrated on the management of the licensed “fishing lots” in the Great Lake and the Mekong and Bassac Rivers. This focus is mainly due to the revenues generated (> US$2 000 000 in annual tax revenue) through the auctioning of the lot licences to professional fishers and business ventures for commercial exploitation. This has a long history as the fishing lot system goes back to the early 1900’s, when the French colonial government established the lot system[6].

Statistics on the productivity of the lots reveal they are very productive, but precise estimates are not available. In recent years the estimates are improving and the official production from the commercial operations was reported to be 442 000 tonnes in 2000, up from 75 000 – 85 000 in previous years. For unlicensed fisheries, such as ricefield fisheries, no such annual statistic is collected. Estimates of ricefield catch (from surveys) differ widely depending on the area and the year of the study. Regional figures vary from a low of 25 kg in Northeast Thailand (Spiller, 1985) through 125 kg in Southeastern Cambodia (Gregory *et al*. 1996) up to 150 kg per ha and year in Malaysia (Ali, 1990). Ahmed *et al*. (1998) used figures ranging from 25-61 kg per hectare and year to estimate the annual production of Cambodia's ricefield fisheries. Multiplied with the 1.8 million hectares of Cambodian rice fields they reach an annual production of 45,000 to 110,000 tons, amounting to 15-25% of Cambodia's total annual fish catch. This extrapolation however is a rather unreliable method of assessment, since the heterogeneity in agro-ecological conditions and differences in the microenvironments of rice fields result in a variable productivity (Little *et al*. 1996). Generally speaking, there is a tendency to underestimate the importance of ricefield fisheries since they tend to yield only small amounts of fish at a time, but on a regular basis and for many people involved.

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[4] Or perhaps a distinction between civilised people and savages.
[5] Defined as fishing in and around the rice fields.
[6] Specifically the 1987 Fiat Fisheries Law formalised fisheries practices, such as the lot system, established in 1908.

Also the diversity of organisms found in the ricefield ecosystem varies according to the place and the year of the study. Heckman (1979) found 19 aquatic animal species being used by farmers in Thailand, whereas Shams and Hong (1998) found 35 species in a study conducted in Kampong Thom Province, and Gum (1997) found 39 species during a survey in Battambang Province[7].

THE STUDY

SCOPE OF THE STUDY

This study was conducted from the middle of September to the middle of December 2001 in Kampong Thom Province, Cambodia[8]. Fish and other organisms were collected from the ricefield ecosystems at eight different locations in three districts of Kampong Thom Province: Stoung, Stueng Saen and Santuk. Two of the places were located closer to the Great Lake with direct access to the flood plain, the other ones at various distances from it along highway No. 6. The maps in the annex show the places where the samples have been taken.

In addition to the information on the availability of the organisms, the tool used for collecting and the ultimate use of each species was collected along with the peoples' preferences among the different species. Any additional information found has been added under the heading of traditional knowledge and observations.

LIMITATIONS OF THE STUDY

The abundance of fish and fishers is extremely seasonal in the area. The study began in the middle of September and thus the beginning of the fishing season has been missed. No attempt has been made to weigh the organisms caught by the fisher-folks involved in the study, since the day to day variability of the catches was too great and the scope of the study limited to three months and eight locations.

In terms of overall abundance and availability certain groups of animals are underrepresented here since, according to the local people, their "season" is either before the start or after the end of the study. Important groups include water insects, crabs, some snails, and frogs, which are mainly caught in the dry season and early wet season. Initially the study focused on aquatic animals collected from the rice fields to which aquatic plants were added later.

METHODS USED

To collect information from the local people, several different methods were used sequentially. The study was initiated by conducting Participatory Rural Appraisals (PRAs) in three villages. The second step was collection of information on the organisms caught by the local people. At the end of the study, single and group interviews were used to verify the information previously collected.

PRA

As the first step, PRAs were conducted in the villages of Doun L'a in Stoung District, Panha Chi in Stueng Saen District and Tboung Krapeu in Santuk District. People were asked, during a village meeting, to enumerate the aquatic animals they collect from their rice fields, their uses

[7] For comparison, not restricted to ricefield ecosystems Rainboth (1996) reports 500 species of fish for Cambodia also stating that the real number of species is certainly higher.

[8] It should be noted that in 2000 Cambodia was struck by the severest floods in over 30 years, leaving large areas inundated for months. The floods in 2001, albeit less severe, were still substantial, consequently one would expect a lot of aquatic organisms in 2001.

etc. At the same time the PRA served as an introduction to the people to ensure that they understood the purpose of the following regular visits in their village.

Species collection

From the end of September 2001 to the beginning of December 2001[9], the researchers went to the field almost every day. The maps in the annex show the villages where the collections were made. The collection points were the sites where people went to fish in or near the ricefield ecosystems. The drawing below shows a typical situation in Kampong Thom: the road is built on a dam. Soil for it has been excavated on both sides, forming canals left and right of the road. During the rainy season these canals are filled with water and directly connected to the surrounding rice fields. People gather to catch fish near bridges and culverts, which are like a bottleneck for water and fish.

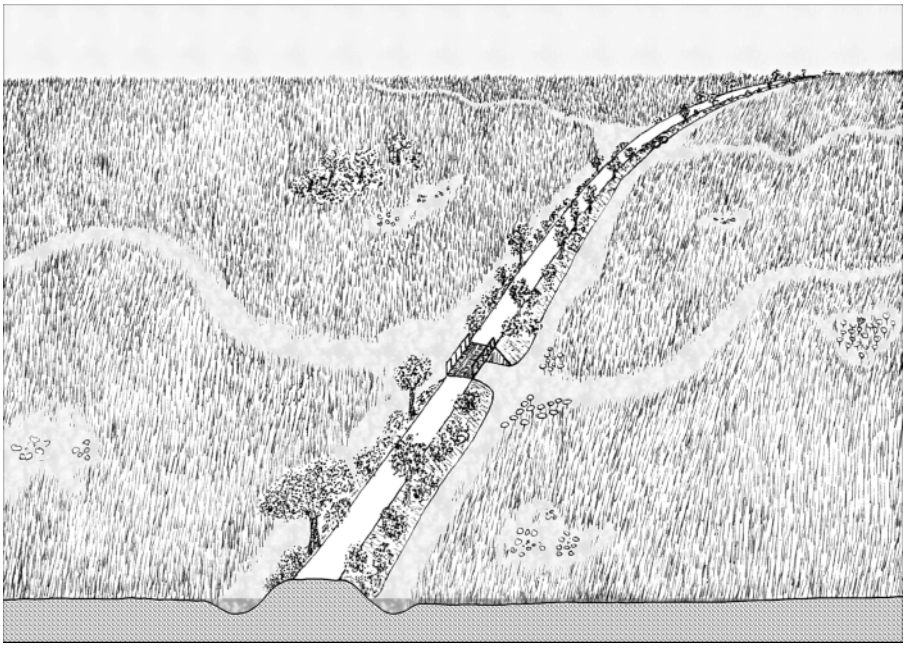

Figure 2. Rice fields and canals all become interconnected in the rainy season in Kampong Thom Province.

At points like this, as well as within the rice fields, specimens were collected and pictures taken of the various species caught. Samples of every organism smaller than 15 cm were collected and preserved for later identification. The pictures were developed locally, then scanned and computer processed. Fish were identified as far as possible, using the field guide by Rainboth (1996)[10].

While collecting the specimens, the fisher-folks were asked to give information on:

- the availability of the species
- their uses in rural community,
- the preferences of the people for them; and
- the various fishing tools used to harvest them.

[9] It should be noted here that the period is covering only the mid of the wet season to the early dry season, but in 2001 the floods were extensive and thus there were much water around even in the early dry season.
[10] The scanned images were sent to Rainboth for verification.

Interviews

At the end of the fishing season, the information collected previously was consolidated and verified in single and group interviews conducted in the villages where the collections were made. Information on preferences was obtained during samplings, PRAs, and group interviews and ranked on a scale from 1 = not liked, 2 = liked, to 3 = highly esteemed. Availability was ranked on a scale from 0 = absent, 1 = rare, 2 = little, 3 = medium, to 4 = abundant, all information obtained in group interviews.

Since the people were by then already familiar with the researchers, no initial shyness had to be overcome. People were talking freely about the aquatic animals they used to collect and also about the difficulties and problems they encounter.

RESULTS AND DISCUSSION

Species found

The species found have been categorized into seven groups: fishes, reptiles, crustaceans, amphibians, molluscs, insects and plants. They are discussed separately below.

Fishes are by far the most important group, both in species diversity and importance for the local population. For most Khmer people fish is the primary source of animal protein and is part of every meal either fresh or in processed form. Catching and collecting animals in and around the rice fields goes on all year round, however most fishing effort in Kampong Thom starts in August and ends in December when the water recedes and leaves the fields dry[11].

In the course of this study 70 different species were found in the ricefield ecosystem. Of the 70 species, 25 were considered abundant and another 12 species were still commonly seen in the catches. Twenty-four species were rated as highly favored. However only four of them were abundant as well: the chevron snakehead (*Channa striata*), broad-headed catfish (*Clarias macrocephalus*), walking catfish (*C. batrachus*) and the swamp eel (*Monopterus albus*). Eleven of the most favored species are considered rare. The availability of the fishes changed during the course of the fishing season; some were more common at its beginning, others were found later. Some fishes came 'in waves', abundant one day and rare the next. The local people claim, that they have seen the eggs of four species within the rice fields, three of them among the most favored fish: the two catfishes mentioned above and the chevron snakehead, the latter being an opportunistic species that can breed all year round. The fourth species is the climbing perch (*Anabas testudineus*), found abundantly but not as well liked as the other three (usually due to its small size, when caught large it is a high value species).

Most fish is eaten fresh, but there are a number of ways to preserve fish. A typical Khmer fish preserve is *Prahoc*, fermented fish paste. It is often made from the least favored fish or from fish left over that cannot be sold fresh any longer. Other ways to preserve fish are to place it in salt, to dry it or to smoke it over wood fire. The latter method results in a highly priced product which is seen less and less in the villages and markets due to the lack of firewood needed for smoking. Two other types of processed fish command high prices in the markets: *mam* and *trey ngiat*. Both are made from the filet of large fishes like the snakeheads, marble fishes, catfishes and other favored species. *Mam* is made by fermenting the filet while *trey ngiat* is sun dried.

Reptiles: Seven snakes and one species of turtle were found during this study. No proper identification could be made on reptiles since no literature was locally available[12]. Snakes are

[11] During the dry season toads, crabs and snails are dug out from the dry rice fields and in the early wet season insects and small frogs add to the catch.

[12] The scanned images were sent to Bryan Stuart for identification.

well liked for food and in some areas have been seriously reduced through over-collection, often for sale to urban markets. Of the snakes found only one was found in abundance, two were seen commonly, especially in the deep water rice fields of Roluos. Snakes are usually eaten fresh, only one snake has been reportedly used as a traditional medicine: preserved in alcohol it is said to enhance the appetite. Snakes can be found in the rice fields throughout the year.

The turtle found is considered uncommon, it has been seen only twice during the course of the study and only in Roluos. It is considered a delicacy and it is also reportedly used as a traditional medicine. A very destructive way of hunting turtles has been described for the dry season: the flooded forest – then dry – is set to fire and the turtles would come out of their hiding places to escape. In the rice fields, turtles can only be found in the months from August to December, during the rest of the year they are found in the flooded forest.

Crustaceans: Five species of crabs and one shrimp have been collected during the study. In his study on ricefield crabs Van Amerongen (1999) suggests that all ricefield crabs found belong to the same genus *Somanniathelphusa* only differing in colour and size with no morphological differences. In this study at least some morphological differences can be seen suggesting that more than one species were found. All but one of the different "types" of crabs were abundant, however, they are not well liked. Commonly used as bait or as feeds for pigs, people would eat them in time of scarcity. In other areas they are often an important source of food in during the end of the dry season when they are dug out of the dry rice fields. Crabs are generally considered a pest in the rice fields where they feed on the rice plants and can do considerable damage to a newly planted field. They are chiefly collected from June to December.

Also the shrimp[13], *Macrobrachium lanchesteri,* is found in abundance. It is used for food either fresh or dried or processed into shrimp sauce. Shrimps can be found in the rice fields from September to December.

Amphibians: Two amphibians were found in the course of the study, one toad and one frog. Since literature on amphibians is not available locally, no identification could be made[14]. Both species are reportedly abundant particularly early in the rainy season (June to September). The frog is very much liked for food and during the season commonly seen in the markets. The toad is used as an anthelmintic for cattle but it is also eaten. It is sometimes exported to China.

Molluscs: One snail was found within the ricefield ecosystem, other snails and also shells were only collected from the rivers and the lakes in the study area. While snail is liked better then crabs it cannot compete with fish and is often used as bait to catch fish or fed to pigs. No species identification could be made due to the lack in literature available locally[15]. Snails are collected in the rice fields from June to December, but in other areas, much like crabs, are an important dry season food dug out of the rice fields.

Insects: Two water insects were found to be of importance for the local people: a giant water bug from the Belostomatid family and a water beetle probably from either the Dytiscid or the Hydrophilid family[16]. Both of them are used as finger foods and both command good prices in the markets following the season for frogs (September to October). The giant water bug is also used as traditional medicine: mixed with alcohol it is given to women after birth. In other areas dragonfly nymphs and other larger water insects are important sources of food in the early wet season (June-August). The water beetle is abundantly available; the giant water bug is still considered common.

[13] Toft Mogensen (2001) identified the shrimp caught in rice fields as *Macrobrachium lanchesteri.*
[14] The scanned images were sent to Bryan Stuart for identification.
[15] The scanned image was sent to Rob Cowie for identification.
[16] The scanned images were sent to Ruth O'Connor for identification.

Plants: Apart from the rice itself there are a number of other plants found within the ricefield ecosystem, which are used by the people in the area. Thirteen species were recorded, six of which were marketed. The other seven species are chiefly used as feeds or consumed locally they have no or a very low market value. All plants recorded were found in abundance, some during the time of the flood, others more towards its end. Of particular importance is morning glory (*Ipomoea aquatica*).

The plants could be identified using Dictionary of plants used in Cambodia (Dy Phon, 2000) and the handbooks of the PROSEA series (2002).

Fishing or harvest methods used

Farmers and fisher-folks of Kampong Thom Province use a wide variety of different implements and techniques to collect fishes and other aquatic organisms from the ricefield ecosystem. In total 26 techniques to catch fish were recorded[17]. They can be subdivided into four main categories:

Baited hooks are rather selective since some species are more attracted to a certain kind of bait then others (e.g. crab eggs is usually good for catching climbing perch). Four different types can be distinguished here, two of which are used actively, and the other two are attached to shrubs or sticks and checked at regular intervals. Baited hooks are also used to catch frogs.

Traps are usually less selective and apart from fish a variety of other aquatic animals like frogs, snakes, crabs and shrimps can be caught with them. Often made from woven bamboo the selectivity is defined by the distance between the bamboo strips. Traps for specific fish exist like the different eel traps. All together, six different types of traps can be distinguished.

Nets, like the traps, are not very selective and the main selectivity is determined by the size of the mesh. Six different types of net were observed. A distinction can be made between nets used actively, like a cast net, and nets placed and left, like gill nets. It was noted that gill nets used in Roluos had a larger mesh size probably since plenty of fish is still available in this area. In areas further away from the flooded plains, like Tboung Krapeu or Tuol Vihear, smaller mesh sizes were employed to catch all but the smallest fish. In these areas many juveniles were part of the catch, which can lead to over-use of the resource. Another particular problem is that old unusable gill nets are left at their position in or near the water being a hazard to many water birds, which get caught and die in them.

Others: Here all techniques and implements that do not fit into the three categories above have been lumped together. They are usually characterized as active techniques such as digging, emptying depressions and catching fish with a spear or by hand.

An additional, illegal and very effective technique has become established during the last decade, electro-shock fishing. It is not a very selective method (though it tends to select for larger organisms) stunning or killing all animals close to its use. It is blamed, along with the destruction of the flooded forest, for the great reduction of the fish catches during the last years.

The implements used to catch aquatic animals can also be grouped according to their use in either shallow or deep water. They can thus also be assigned to periods of time when they are commonly used: a succession of different fishing tools could be observed along with the changing levels of the flood waters in the area.

[17] The Mekong River Commission's Fisheries Programme is in the process of compiling a complete catalogue of the different fishing tools used in Cambodia. A previous study by Gregory *et al.* (1996) recorded 23 techniques.

Most of the implements used to catch fish are traditionally used either by men or women. The elder children, mostly the boys would already support their father in the use of typical male implements, smaller children and girls would accompany the mother in her collecting activities. While both men and women catch fish and crustaceans, plants, snails and insects are rather collected by women and children. Since reptiles and amphibians are typically caught with fish traps, men are the ones collecting them.

Some farmers have established ponds in or near their rice fields. These are not usually stocked actively with fish but the fish enter them from the surrounding rice fields when those are drying up[18]. Some farmers would also place small fish caught during the end of the flooding into their pond to allow them to grow bigger. However, most farmers do not have such a pond, because the soil in their area is not suitable or that they cannot afford the time needed to dig such a pond deep enough to retain water throughout the year. They declared that if an organization would support them they would readily agree to have a pond[19].

Traditional knowledge and observations

Over time people have accumulated a profound knowledge about fishes and their behavior. They have very detailed understanding about what kind of fish can be found where and when[20]. A common observation is that many fishes lay their eggs in the flooded forest or in the flooded shrubs surrounding their rice fields. The fingerlings then come to look for food in the rice fields and the flooded grasslands. Another observation is that once the trees and shrubs are gone in an area, the abundance of fishes is reduced.

People in the area have observed that over the last two decades fish catches have been greatly reduced, and some fish species have disappeared all together. This is blamed partly on the increasing use of illegal fishing tools like electro shock but also on the destruction of the flooded forests surrounding Tonle Sap Lake[21]. The increased number of people living in the area, and thus fishing in the area, is also given as a reason for the diminishing catches. In fact it is likely that the total catch in the area has actually increased as a result of increased fishing pressure[22] (i.e. greater number of people fishing), but the individual catch as well as the average size of individual fish have dropped.

On average, a family of five persons would consume about one kilogram of fresh fish every day during the fishing season, and the same family would need about 20 kg of *Prahoc* to eat during the dry season, amounting to a total of some 200 kg of aquatic animal products annually for the family. Other studies (e.g. Ahmed *et al.* 1998) indicate that fish consumption around the Great Lake is around 60-70 kg per person per year (fresh weight equivalent) totaling an annual consumption of about 350 kg for a family. In other areas of Cambodia the consumption is estimated at around 40 kg per person per year (Gregory *et al.* 1996, APHEDA 1997, Shams and Hong 1998, Gregory and Guttman 2002a).

[18] For further reading on this please refer to Gregory (1997) and Guttman (1998 and 1999).

[19] It should be noted that the Family Food Production (FFP) programme dug some 20 000 ponds in Cambodia during the early 1990's.

[20] The MRC Fisheries Programme has compiled a study on local knowledge of fisheries in the Mekong River basin (Bao *et al.* 2001).

[21] It should be noted that in the beginning of the 1980's the area of flooded forest cover was greater than in the late 1960's, due to the reduction in rice cultivating areas around the lake during the 1970's.

[22] As a comparison the population in Cambodia has grown from an estimated 8.5 million in the early 1980's to just over 11 million in 2000, an increase of almost 30%.

A more market-oriented approach drives people to catch more fish for sale in the markets. Depending on the fishing tool employed, a farmer-fisherman can catch 15 to 20 kg of fish on a good day. The average fish catch during the fishing season is less than 10 kg per day. However, this is still very small scale in the Cambodia context where a fishing lot operator can catch about the same amount of fish in less than ten minutes by blocking the migration route of fish in a medium sized river. Recent changes in the Cambodian fisheries legislation are dismantling a number of the fishing lots to be converted to co-management operations by surrounding communities.

The effects of the disease epizootic ulcerative syndrome (EUS), locally known as *dambao*[23], which spread throughout Southeast Asia in the mid 1980's are still noticeable and is reported to occur every year with varying strength. Most noticeable in the period January to March, fishes (most susceptible are snakeheads and catfishes) in ponds and lakes start dying of big ulcers, but by the onset of the rains the disease disappears. Local people say that these fish cannot even be used to make *Prahoc*. The worst year in memory was 1995 when most lakes were transformed into stinking pits[24]. People claim that the increasing use of fertilizer and pesticides in the receding rice cultivation is to blame for this phenomenon. Epidemiological studies show that the disease spread to Cambodia in 1984 and has been endemic since then (Lilley *et al.* 1992).

Local people believe that on Buddhist prayer days many fish can be caught. Since Buddhist prayer days coincide with the phases of the moon, this is supported by another observation: fish like the moonlight, they are playful in moonlight and are easily caught with gillnets at full moon. When rain is coming up, however, no fish can be caught. Only when the rain starts falling the fish would come out of their hiding places. During certain times of the day, very little fish is caught. Asked for the reason, a fisherman told that the fishes are now in the rice fields looking for food. They would come out later to play in the canal where they can be caught with the cast-net.

CONCLUSIONS

The ricefield ecosystem is of major importance to the local population for the supply not only of rice but also of animal protein and vegetables. Development that only focuses on increasing yields of rice through intensification and the use of chemical fertilizers and pesticides may possibly give the people more rice to eat, but it may, as pointed out by Guttman (1999) and Gregory and Guttman (2002a), take away much of the aquatic animals and vegetables also harvested from and around the rice fields. This is an important point since the current agricultural policy is to further develop the rice production in Cambodia[25]. Without a sound understanding of the other components of the ecosystem and careful preparation of suitable extension there is a great risk that the aquatic animal production can be severely affected. Importantly, it will be the poorer segments of rural society which will suffer most from the negative impacts of such development.

[23] This is what local people call it; the word actually means that the fish has skin ulcers and wounds.
[24] Also in other areas of Cambodia the years 1995 and 1996 were seen as especially bad with respect to EUS incidence.
[25] A very understandable goal since on average the yields are poor, averaging around 1.4 tonnes per ha per year (Javier 1997), well below the world average of 3.8 tonnes per ha (IRRI 2002).

With the increased fishing pressure there is a growing perception that what is needed is introduction of pond culture stocked with (often exotic) fishes. However, caution is advised here (Halwart *et al.* 2002). Small-scale pond culture is unlikely to produce large amounts of fish to fill the increasing (or developing) gap between supply of naturally available fish and demand of the growing population. In the study areas it is at best difficult to maintain a fishpond during the flooding period when most of the area surrounding the Great Lake becomes flooded. The amount of fish produced in small-scale low input ponds is correspondingly low, averaging a few kilograms to a few hundred kg per family. As an illustrative example, the development of small-scale aquaculture took off dramatically in the southern province of Svay Rieng in the mid-1990's with the support of intensive aquaculture extension. After five years the number of households farming fish had risen from virtually none to a total of 1 300 households producing some 50 tonnes of fish (Gregory and Guttman 2002b). This is less than one percent of the estimated provincial production from rice fields, swamps and rivers, estimated at 5 000-10 000 tonnes (Guttman 1999). Small scale aquaculture has a great potential in providing fish in areas where fish is scarce[26], and can successfully address needs of poorer sections of rural population, but it cannot provide large amounts of fish for a growing population (although commercial intensive aquaculture is capable of this).

A more promising approach seems to be a participatory development approach that addresses all the needs of the local people through locally developed natural resources management plans and a more holistic view of a system that has catered the needs of the people for many generations[27]. The difficulty is perhaps to know where to start. A few pointers have emerged over the years. Firstly, it is important to make sure that enough adult fish survives the dry season. In a monsoonal flood pulse environment like the Great Lake (and much of the Mekong River Basin) this means that enough dry season refuges are available, either in the lake or in swamps and ditches around the lake. This is sometimes contrary to current practice since the best places to fish are in the dry season refuges as they tend to have a lot of fish and little water. Secondly there is a need to make sure that the migration routes out of the refuge are unhindered, so the fish can reach the spawning grounds or fry can reach the nursing grounds[28]. Finally there is a need to determine the aim of the fishing effort, equity or efficiency. If efficiency is sought (i.e. as much fish for as little effort as possible) it is often better to have a smaller group of specialised fishermen undertaking the fishery. If however equity is desired then small 'inefficient' gears are to be favoured making it possible for a greater number of people to be involved in the fishing.

More practically resources must be managed with a more holistic view. Hoggarth *et al.* (1999) provides general advice in how to manage flood plain river fisheries, and identifies several levels of management units (national, catchment, intermediate and village level). The same paper also identifies the different management categories; environment, who has access, amount and type of fishing and fish stock enhancements. One successful strategy has been to encourage villagers to protect their dry season refuges to ensure that there are sufficient stocks for the following year. This is an intuitive and practicable solution that has been successfully introduced in some areas. Other solutions are to agree on certain fish catch methods during certain periods (this is practiced traditionally in some areas), to reforest/improve spawning and nursing habitats (possible if the areas are also under some environmental protection) as well as making sure that infrastructure development (such as roads) are not blocking important wet season migration routes for fish.

[26] Demaine and Halwart (2001) discuss various forms of interventions in an overview of rice-based small-scale aquaculture.

[27] An overview on thoughts and lessons collected by DFID and FAO in 2000 with regard to participatory approaches for aquatic resources management and development is given in Halwart and Haylor (2001).

[28] Guttman (1998) provided a schematic illustration of the migrations of fish in a lowland flood pulse environment.

Finally, the ricefield ecosystem is a traditional modified ecosystem, its diversity and productivity is high making it a suitable system for low input farming. Intensification and specialization of the system will be associated (in most cases) with losses in some of the other products. It is therefore especially important to assess what those changes will be, who will benefit and who will loose, and to try to find ways to minimising the losses and maximising the gains.

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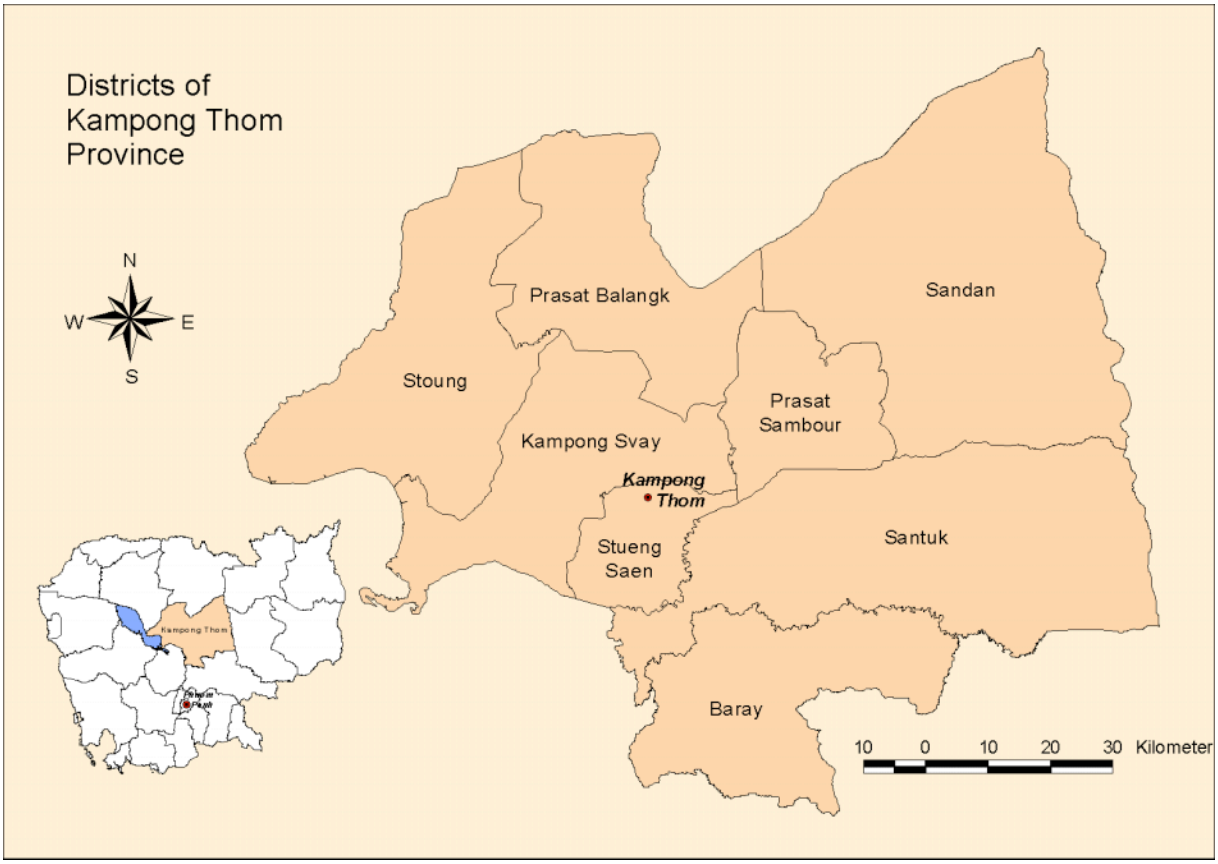
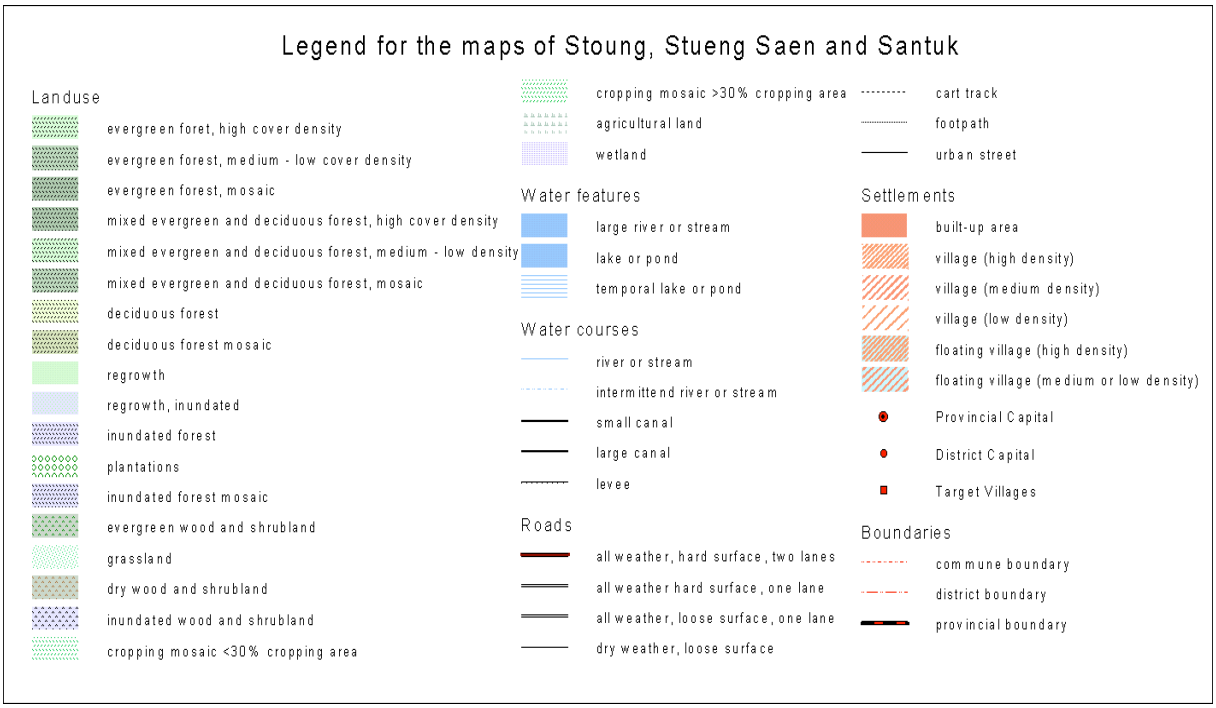
ANNEXES

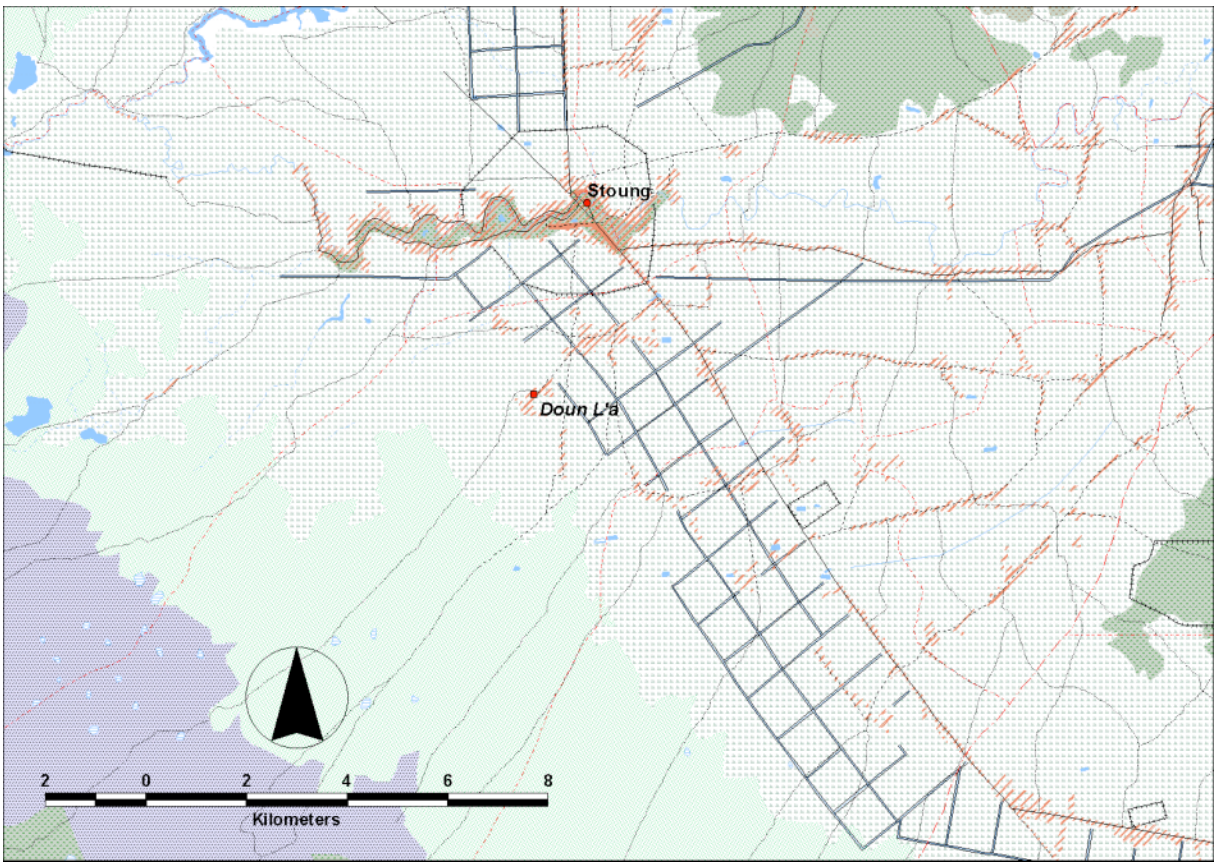
Annex 1. Districts of Kampong Thom Province, Kingdom of Cambodia



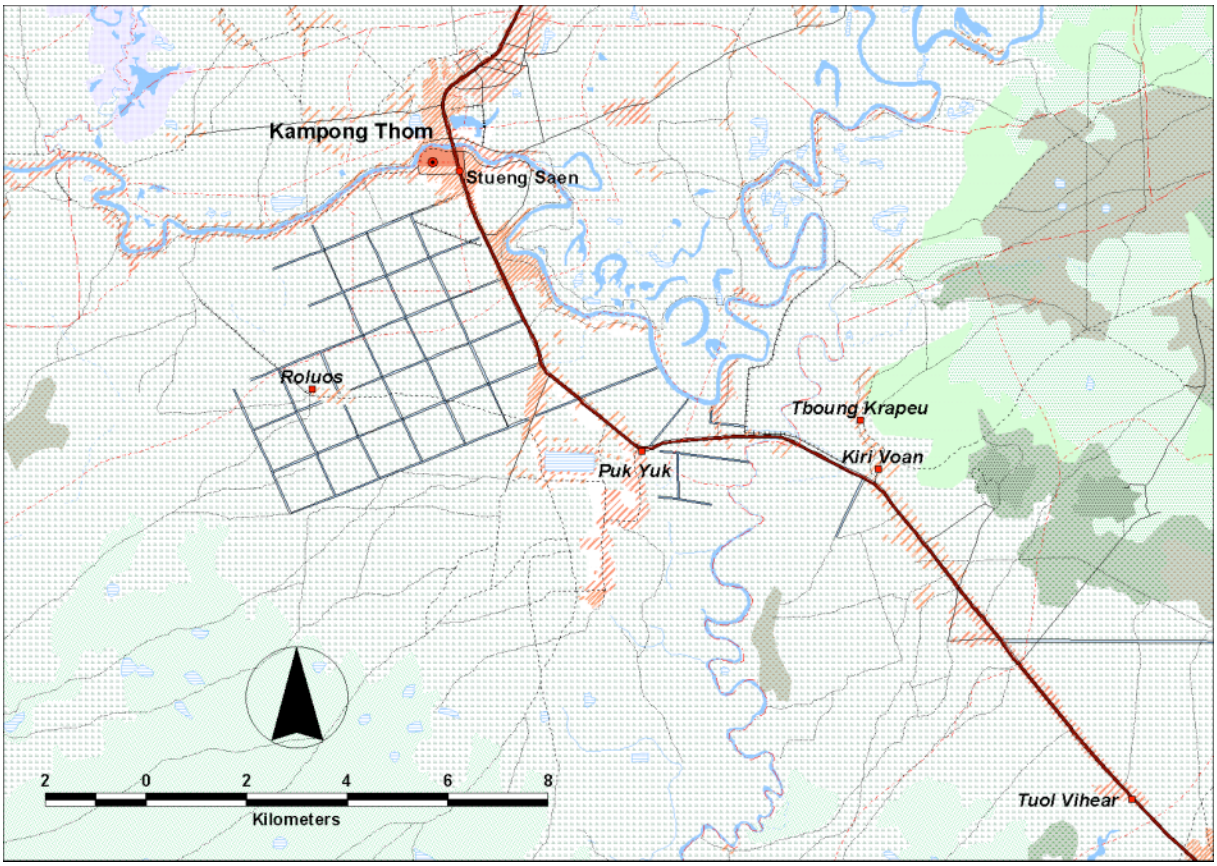
Annex 2. Legend for the maps of Stoung, Stueng Saen and Santuk districts.



Annex 3. Map of Stoung district (for legend please refer to Annex 2).



Annex 4. Map of Stueng Saen district (for legend please refer to Annex 2).



Annex 5. Map of Santuk district (for legend please refer to Annex 2).