FACTORS THAT DRIVE CAMBODIA'S INLAND FISH CATCH: WHAT ROLE CAN COMMUNITY FISHERIES PLAY?

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For sustainable development of inland fisheries in Cambodia

WorldFish CENTER

POLICY BRIEF

FACTORS THAT DRIVE CAMBODIA'S INLAND FISH CATCH:
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John Kurien, Eric Baran, So Nam

Understanding all the variables that affect aquatic ecosystems and attempting to establish the linkages between them are daunting tasks. In the case of inland waters, particularly where large floodplains are involved, this process is made even more complex because of the fluctuating land-water interfaces which are an important and determining characteristic of these ecosystems. Simple methods to establish the relationships between the ecosystem variables and utilise them for taking informed policy decisions that link the environment, fish resources and the people who depend on them are an important beginning in such situations.

This policy brief is based such an initiative being made at the Inland Fisheries Research and Development Institute (IFReDI) in Cambodia to model the crucial hydrological, bio-ecological and socio-economic factors that deserve attention if the fish catch in Cambodia is to be sustained. The knowledge gaps still hampering the management of the fish resource are highlighted, as well as avenues to overcome these problems. This is followed by examining how the development of the unique institutional arrangement of community fisheries, promoted by the Government and put in place by the Department of Fisheries, will influence the variables. We also consider the ways by which community fishery organisations can become effective partners in contributing to the data and information required for an improved management of the evolving ecosystem. Finally we point to two issue -- pollution and aquaculture activity -- which are yet to be taken into consideration as playing a significant role in the sustainability of the inland fish resources in Cambodia.

EXCEPTIONAL IMPORTANCE OF INLAND FISHERIES IN CAMBODIA

Since 2000 Cambodian inland capture fisheries ranks 4th in the world in terms of total catch. This is considerable as the country is rather small (181,035 km^2) and its population is small too (13.6 million in 2005). Actually, with an average 20 kilograms of freshwater fish caught per Cambodian per year, the country has the most intense inland capture fisheries in the world.

Thus according to FAO statistics in 2001 and 2002, with 398,000 tonnes and 374,000 tonnes, the inland fish production of Cambodia was superior to that of the USA and Canada together (323,000 and 340,000 tonnes). As a consequence fish is

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a major natural asset for Cambodia, like nickel in New Caledonia or diamond in South Africa: freshwater fisheries contributed 10 to 12% of Cambodia's GDP in the past years. This is a very conservative value given the undervaluation of the resource highlighted in several recent reviews. When considered in live-weight equivalents, the catch of Cambodian fisheries represent, in tonnes, 10 percent of the rice production, 3 times the pig production and 20 times the chicken production of the country. In fact, recent re-assessments of the fish catch based on consumption studies taking into account human population growth conclude that the total fish production of the country amounts to 600,000 tonnes and even 682,000 tonnes. These assessments are not reflected yet in official statistics.

NEW INITIATIVES TO BETTER ASSESS AND MANAGE THE FISHERIES

The last decade has witnessed several initiatives by the governments, inter-governmental agencies and research institutions with the assistance of international agencies to improve the management of the aquatic resources. Some studies and assessments have been commissioned to review and make better judgments about the qualitative and quantitative dimensions of the aquatic ecosystem. This vast, rich and complex system is characterized by inadequate scientific assessments which still hinder its efficient management. However in the past three years at the Inland Fisheries Research and Development Institute (IFReDI), new surveys, studies and approaches have contributed to narrowing the knowledge gap, and have highlighted a number of facts about the close link between the natural environment and the fish stocks.

INTEGRATING KNOWLEDGE ABOUT FISH RESOURCES AND FISHERIES

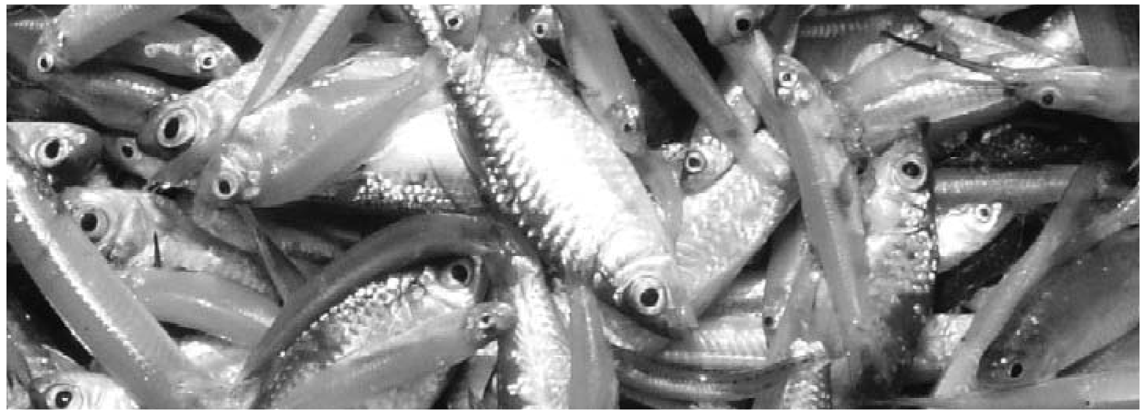
Four variables determine the availability of fish at markets in Cambodia: the hydrology of the river system, the quality of the floodplain environment, the possibility of fish migration and an efficient fishing sector. Our understanding of how these variables are linked is based on a series of bioecological reviews and analyses integrated in a Bayesian network model focussing on the Tonle Sap Great Lake (See Box 1). We first detail the three components belonging to the ecological realm and then consider the last factor belonging to the socioeconomic realm.

Box 1 : Bayesian networks to integrate knowledge about the resource

Given the deficiency of reliable data, scientists are obliged to devise a portfolio of methods to make assessments about the important biological dimensions of the fishery resources. One such method has been Bayesian network models. They are basically simple (but sometimes looking complicated!) diagrams that organize knowledge about a given topic (area, realm) by mapping out cause-effect relationships among key variables and assigning them with numbers (probabilities) that represent the extent to which one variable is likely to affect another. Bayesian networks help structuring our knowledge about a subject by stressing on the relationships between variables.

In the case of the Tonle Sap fish production, the BayFish - Tonle Sap model identifies a few key interacting variables characterized either by data from databases or by qualitative information (domain knowledge) obtained from those who know the fishery best (fishers, field officers, scientists). The model thus defines the aquatic system as a network of variables which are connected by probabilities; it allows assessing how much a modification of a given variable will influence a target variable, here the fish production.

An important limitation of the Bayesian model is that it is static. Despite this limitation, a Bayesian network can cope with a data scarce situation and inform decision makers, civil servants and other stakeholders, on the basis of best available knowledge, about the relationships, trade-offs and trends within a given system.


picture by Dr. So Nam

Hydrological variables that drive fish stocks

There are three important hydrological factors that determine an abundant fish stock: water level, duration of the flood and timing of the flood.

- The water level reached by a flood is considered the most important factor; it determines the surface area accessible to fish to breed and feed during the rainy season. Man-made modifications such as dams that would permanently reduce this water level would negatively impact the fish stock. Since the 1950s more than 800 small multi-purpose dams with reservoirs and often extensive irrigation schemes were built in Cambodia. This has also led to the fragmentation of aquatic habitats and the blocking-off of fish spawning areas.
- The duration of the flood is the second most important parameter influencing the size of the fish stock. A short flood does not leave enough time for fish to take advantage of the resources available in the floodplain; subsequently fish do not grow optimally and the overall stock biomass is reduced. Conversely a long flood is beneficial to the fish biomass.
- The date of flooding is the third hydrological parameter driving the size of the fish stock, an early flood being beneficial to larvae and juveniles that have better environmental conditions and a longer flooding season to grow.

Floodplain environment variables that influence fish stocks

The floodplain environment is conditioned by two main parameters which have a bearing on fish stocks: the nature of the flooded vegetation and the possible presence of built-structures or every type which hamper flooding and migrations.

- It is believed that the most favorable habitat for fish is the flooded forest, followed by shrub land and by grassland. Clearly higher habitat diversity allows a higher species diversity. However the surface area of flooded forest has dramatically decreased over years. That of shrubs and of grassland (including rice fields) has increased. The clearing of flooded forest is motivated by the need of land for rice farming, but at the scale of the basin the tradeoff between increasing rice production and decreasing fish production has never been considered, let alone quantified.
- Following development in the countryside, an increasing number of roads, dykes and weirs are being constructed. If not adequately designed (e.g. enough culverts of sufficient diameter under roads), these structures prevent or reduce the flooding of certain habitats in the floodplain, restricting the habitat

picture by Kent Hortle

accessible to fish. The number and impact of built structures in Cambodia has never been assessed. Large scale fishing gears, in particular the hundred kilometers of barrage fisheries, also classify as built structures; if their role in the fishery is well known, their impact on the hydrology of the floodplain system has not been adequately considered either.

Fish migrations and refuge variables that condition fish stocks

Fish migrations are an essential feature of Mekong fishery resources. They allow fishes to move from feeding grounds to breeding grounds and to refuges. In the Mekong system these migrations are crucial in allowing fish to complete their biological cycle between feeding and breeding grounds, ponds in the floodplains, deeper areas of the Tonle Sap Lake (including some fish sanctuaries) or deep pools in the Mekong mainstream.

- A number of flood plain residents (black fish species) spend the dry season in the ponds of the floodplains or in some parts of the deeper areas of the Tonle Sap Lake (including some zones defined as sanctuaries). With the increased fishing pressure and the development of techniques that consist in pumping these flood plain ponds dry, these species have been subject to radical harvesting, without a possibility to breed the following season. There is also a need for an assessment of the Tonle Sap Basin areas that would constitute the most efficient fish sanctuaries.
- The essential shelters for long distance migrants (white fish species) are the deep pools in the Mekong mainstream, where it has been recently demonstrated that large individuals (white fish) concentrate during the dry season, in particular Pangasiid catfishes. In the dry season the catch-per-unit effort is three to twelve times higher in these deep-water pools than in the surface and the average weight of individuals caught in depth is substantially larger than near the surface. These big individuals are breeders and produce a high number of eggs and larvae, and thus play an important role in the sustainability of a fish population. Protection of these pools is a strong requirement for sustained catches in fisheries.

Fishing activity that finally yields fish

Fishing, which finally harvests the fish stock, is largely determined by two parameters: the number of fishers and the fishing effort (both its amount and quality) which they exert on the resource.

- In Cambodia the number of fishers is an elusive figure given the variety of activity patterns adopted by people living in riparian communities; it can only be said that the population living around the Great Lake increased from about 0.36 million in 1940 to 1.2 million in 1995, making about 11 percent of the total population. This number is likely to have increased in the last decade. The seasonal variations, the adoption of different sorts of fishing gear and the inherent occupational plurality made the task of making this assessment very daunting.
- The fishing effort is even more difficult to assess given the above profile of the fisher. While a census of fishing gears may be feasible (though costly) it will not provide an indicator of the quantity of effort without a clear understanding of gear use patterns across time and space. Moreover, the quality of effort -- whether it is benign or harmful to the resource -- is an important factor which deserves to be closely monitored.

The variables we have described above which are crucial to ensure sustained fish catch are presented schematically in Figure 1 below.

The variables we have enumerated are not static. They may be influenced in future by several factors both close to and distant from the sector. Currently very little is known about the status and details of the fish resources and the fisheries that depend on it. For instance there have been a number of studies, limited in time, about fish consumption or production, but there is currently no field-based scientific monitoring of the overall fish stock and fishery in Cambodia. (See Box 2)

CAN COMMUNITY FISHERIES INFLUENCE THE FACTORS THAT DRIVE CAMBODIA'S INLAND FISH CATCH?

In many parts of the world there are vibrant discussions today about the role and the relevance of co-management of fishery resources in inland and marine ecosystems -- sometimes referred to also as community fishery arrangements. Globally there are also several efforts being undertaken, at local and national levels, to create the organisational arrangements for implementing co-management measures.

Cambodia recently placed large tracts of the aquatic terrain under regulated community

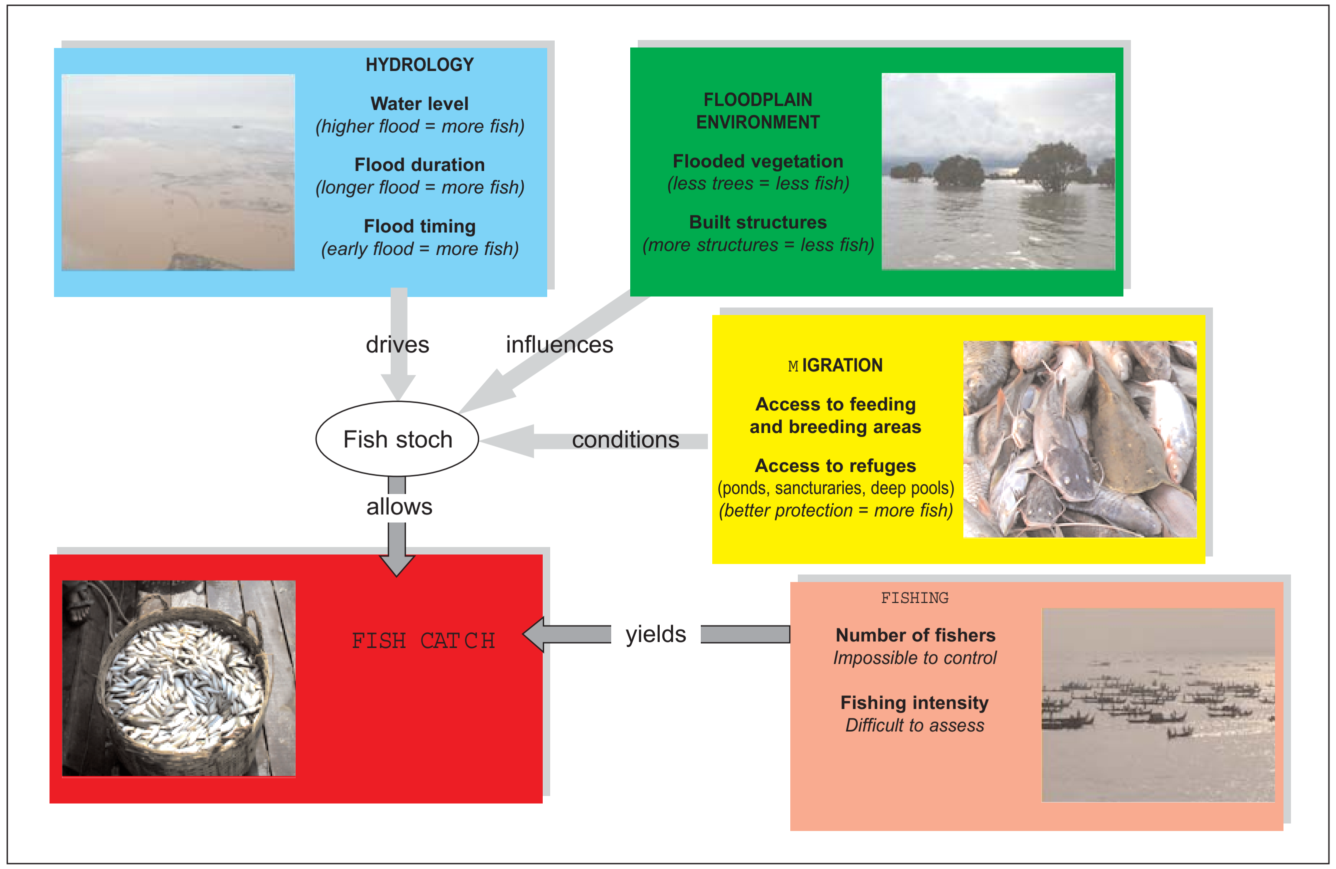


Figure 1: Variables Affecting Fish Catch in Cambodia

Box 2 : Status of scientific knowledge on fish and fisheries in Cambodia

- The information on fish growth is available for only 8 percent of fish species, diet is known for only 6 percent of them, and information on reproduction is available for just one fourth of these species. There is no information about the ecology, population dynamics and population genetics of most fish species.
- The relationship between diversity, density and extent of floodplain vegetation or habitats and fish stock or catch has never been quantified.
- The scientific assessment of the catch of subsistence fisheries (roughly one-third of the total catch) is based on household consumption studies led in 1995-1996. There has been no field-based update of the scientific assessment of the catch of the mobile gear and lot fisheries (about one quarter and one-fifth of the total fish catch respectively) in the past 10 years. The rice field fisheries (a quarter of the catch) have never been scientifically assessed on a large scale.
- The dai fishery is the only fishery currently monitored; it represents only 4 to 5 percent of the overall fish production and is specialized, targeting long distance migrant species, especially small cyprinids (i.e. *Henicorhynchus spp.*) which contributed about 50 percent of total dai fish catch in 2004.
- The estimates of the number of persons who earn their livelihood from fishing and about their socio-economic conditions are also very sketchy. These estimates were also made in 1995 and this source is quoted ad infinitum or updated using guesstimates of trends.

access with usufruct rights. In the near future there will be a mosaic of community fishery areas along the riparian tracts of the Tonle Sap. The households which become members of these organisations will have the rights as well as the responsibility to care for the resource and benefit from it. One of the specific objectives of Community Fisheries is to increase the community's understanding and recognition of benefits of the fisheries resource through participation in the protection and management of the micro-ecosystem assigned to them.

Taking an optimistic view of the future, we assume that communities will take this task of nurturing the resource and the environment seriously, and will be helped by fishery scientists and other researchers to do so. The context, the required skills, infrastructure and commitment to undertake this challenge can be easily developed in Cambodia. It will required the organised effort by research institutions such as IFReDI, the Community Fishery Development Office (CFDO) of the Department of Fisheries and a consortium of competent civil society organisation working together with the newly formed Community Fisheries organisations. Should this be the case we have two issues to consider before us:

1. What is the bearing and the impact which Community Fisheries organisations will have on the interacting variables described in the model that influence fish stock and fish catch?
2. What can be the role of Community Fisheries organisations in gathering information or data about ecological and socio-economic variables whose monitoring is essential to management?

Impact of Community Fisheries on the factors that drive the fish catch

To a certain extent, Community Fisheries organisations can influence all the main variables and their parameters identified above. The influences of the Community Fisheries over these variables, because of their decentralized and small-scale activities, may take the form of 'small incremental changes' until they reach a threshold level. After this their effects may become evident on the whole Tonle Sap aquatic ecosystem. This is an important dimension which we should bear in mind. An indication of the variables and parameters that may be influenced is given in Table 1. We also elaborate on some of the realms where considerable influence will be exerted by CF on the variables.

Fishing

The most important influence of CF will naturally be on the variable fishing. Given that small-scale subsistence fisheries will dominate CF activity there will be an increase in small-scale fishing effort in the near future. With the tax on middle-scale fishing being removed this will only further intensify effort. The use of legally approved, benign nets and traps may not harm the resource though the catch per unit of effort will decline. The problem lies with increased use of destructive fishing methods to obtain quick returns.

Whether the number of persons involved in fishing will increase is difficult to assess. On the aggregate and in the short run it may increase given the new freedom of access to the aquatic ecosystem.

Floodplain Environment and Fish Migration

The next variable which can be significantly influenced by the Community Fisheries is the floodplain environment. There will be many CFs where numerous members are more concerned about use of the floodplains for agriculture than for fisheries. This can prompt them to drain out water from recession pools in the floodplains that are also dry season refuges for floodplain fish species. It may adversely affect local fish stocks. On the contrary if most of the CF members are more oriented to fishing activity as their main occupation quite the opposite may result -- they may act judiciously and collectively to protect the floodplains and fish refuges.

With regard to built structures too the impact will depend largely on the activity and composition of the members of the CF. There have been examples of community actions vis-à-vis the construction/removal of micro-level built structures (channels and weirs) that have had positive impacts on the hydraulics of the local eco-system. For example, in Bak Emrek Community Fishery (CF) in Battambang Province, taking the case of the floodplain environment and the built structures variable, the members pointed to the higher fish catch of the river adjacent to the CF area. They attributed this to the decision of the community members to remove all the obstructions in the flood plain channels which were put up by the former lot operators. As a result more women and children are able to catch fish for consumption and processing very close to their homes along the river bank. The river was not part of the CF area and was an open access realm. This change of an envi-

Table 1: Community Fisheries and Variables

Variable	Will Community Fisheries Impact It?
Fishing	
Number of fishers	YES (considerable in the short run)
Fishing intensity	YES (considerable)
Floodplain environment	
Flooded vegetation	YES (considerable in case of agriculture activity)
Built Structures	YES (minimal but cumulative)
Fish migration	
Access to feeding and breeding areas	YES (considerable)
Access to refuges (ponds, sanctuaries, deep pools)	YES (ponds, sanctuaries) NO (deep pools)
Hydrology	
Water level	?
Flood duration	?
Flood timing	?

ronmental variable (the local hydro-dynamics) followed the shift to the CF regime. There are likely to be a vast variety of such alterations causing both positive and negative impacts.

Hydrology

CF activities will have the least bearing on hydrology at the scale of the whole basin. At this level the hydrology will continue being influenced by policy and investment decisions taken both at the national level and outside Cambodia. In the case of national policies, the decisions will be largely in the interests of sectors of the national economy and by government departments which have much greater say on national priorities and development issues. The most important of these non-fishery sector impacts is that of dams. (See Box 3)

Educating Community Fisheries members and involving them in data gathering

It is important to note that the impacts on changes for each of these variables can be positive or negative. This highlights the greater need for close and continuous monitoring of the variables and the related changes. As our knowledge of the inland aquatic system expands, the inclusion of more variables to be managed might become necessary. But lack of data and information, highlighted above, will remain an impediment in doing so. Conventional biological and ecological data gathering methods are costly and also not necessarily as accurate as they seem. Innovative efforts to fill the data and information gaps in collaboration with CF can be cost-effective and mutually beneficial.

Intervening in the micro-ecosystem will throw up many new insights for both the community and researchers. There will be opportunity for new learning for both. It will also call for new methods of data collection with greater participation of the community. Developing a set of key 'indicator attributes' to make an assessment of the variables becomes a priority. We need to take each variable which has been identified as having potential to be influenced by Community Fisheries actions and work out with the community how exactly the cause and effect relationship operates. Where possible the qualitative and/or quantitative indicator for measuring it can also be devised.

Integral to such a participatory approach is that the results of the exercise be discussed

Box 3 : Dams alter hydrology and subsequently impact fish stocks

As dams store water and release it in a controlled manner, they significantly influence the timing of floods, as well as they influence their amplitude. A recent study assessed the impact of different water management scenarios on flows and on a number of indices, including a fish habitat availability index (HAI). The study concluded that the expected loss to the HAI ranges between 1 percent and 13 percent for the area downstream from Kratie. Assuming a catch varying conservatively between 290,000 and 430,000 tonnes in Cambodia, this would correspond to a loss of 2,900 to 55,900 tonnes of fish with a monetary value ranging from USD 2 million to USD 38 million..

An analysis of the response of 47 fish taxa to discharge at the border between Laos and Cambodia shows that the highest biodiversity in catches correspond to the lowest water levels, and that 55 percent of taxa studied are highly sensitive to discharge, whereas 17 percent are not. Among commercial fish, most taxa have a migration peak at the end of the dry season. This underlines the crucial importance of dry season flows (and the impact of their possible alteration) for Mekong fishery resources, at the time when fish are most dense and fisheries very intensive.

One of the consequences of dam building is the creation of a reservoir. Fish catch from reservoirs is often presented as a compensation for the downstream loss of fish; however an analysis of the information available in the MRC Mekong Fish Database shows that in the Mekong Basin, only nine species out of 768 are known to breed in reservoirs.

picture by Dr. John Kurien

with the community to obtain feedback. For the community, this information which provides them greater understanding of their micro-ecosystem, is also a source of empowerment for their own progress. Training volunteers for such assessments will be an initial task. Fishery researchers must involve in this process. They can seek the participation of provincial fishery officers and civil society organizations.

IMPORTANT UNACCOUNTED FACTORS

Two important and rapidly emerging factors have not been integrated to the approach detailed above, although they will have an important bearing on inland water fish stocks in Cambodia: pollution and aquaculture.
Pollution has two main sources: households and agriculture. Household organic pollution is at the moment mainly limited in the Tonle Sap to floating villages -- in particular during the dry season. But the situation will change rapidly with the exponential development of urban space in Cambodia. For example in Battambang, located by the Sangkae River (the biggest tributary of the Tonle Sap Lake) the population has now reached more than 124,000 inhabitants and is the second biggest city in Cambodia. Then there is Siem Reap with 83,000 but more than one million visitors a year spewing large quantities of unprocessed urban effluents into the Tonle Sap Lake at Chong Khneas. Agriculture development also poses a major threat to aquatic resources in Cambodia. The development of agricultural projects around the lake will be concomitant with the increasing use and release of pesticides and herbicides in the aquatic system. Experience from the Mekong delta has shown that the bearing of this pollution on the brood stock of many fish species (especially floodplain species) can be considerable. Monitoring pollution and taking proactive measures to reduce it need to be given high priority in Cambodia for the sake of the integrity and sustainability of the invaluable aquatic resource of this country. Here too the Community Fisheries organisations have great potential to play the role of 'beacons of the aquatic environment'.

The enthusiastic development of aquaculture in Cambodia is another variable to watch with caution. In Cambodia, the production of aquaculture amounted to only 26,300 tons in 2005. This represents just 8 percent of the total inland capture fish production or less than a tenth of what people eat. It is estimated that more than 70 percent of inland aquaculture production is entirely dependent on wild fish both for seed and feed. Fingerling supply from the wild is significantly higher than from the hatcheries. Information from a recent study highlights that Cambodian aquaculture (including crocodile farming) depend highly on sourcing for low value inland water fish species as dietary nutrient inputs. In fact, in 2005 more than 40,000 tons (about one-fifth of the total inland capture fisheries production) of inland low value fish (consisting of at least 62 different species) were used for producing inland aquaculture production in Cambodia. Today, it is still the capture fishery resources that provide food to millions in the country. Using captured fish to feed cultured fish that is then sold on the market may be an economically profitable proposition for those who control these activities. However, it can become unsustainable both from an environmental and an energy balance perspective and adversely affect the food security and livelihood of many.

Subsequently the priority for the region should be to protect and optimize the exploitation of its huge natural capital. This can be coupled with the simultaneous development of a decentralized and adaptive, low energy input aquaculture sector as a viable supplementary option to raise the level of fish produced in Cambodia. With committed policy guidance, good science and sound extension services, the community fisheries organisations can also play an important role in this.

CONCLUSION

This policy brief has attempted to highlight the exceptional importance of inland fisheries to Cambodia. This significance pales before the contradiction between the dismal state of data and the information needed to monitor and manage this resource which is important for the people and the economy. Innovative methods for overcoming this data deficient circumstance are few. Network models, though not a substitute for good data, provide a framework for listing the variables and understanding the relationships between them in this context.

It has been highlighted here that there are three groups of crucial variables that drive the size of the fish stock: hydrology, the floodplain environment and fish migrations. Human activity affects all of these variables, and is also responsible for fishing, that harvests the fish stock.

We have assessed the manner in which Community Fisheries -- the new institution being put in place by state and society -- will influence these variables. We infer that the impact can be significant -- particularly when viewed on an aggregative basis. However this new institutional setting also provides a starting point for exploring how people close to the resources can be involved in the monitoring of the variables which affect it.

Two more variables linked to the socioeconomic realm will also influence the aquatic ecosystem and fish resources and deserve closer attention: pollution arising from urban and agriculture development and aquaculture. Here too, appropriate policy guidance, good science and sound extension services to the community fisheries organisations can also play an important role in both assessing and mitigating ill-effects. Informed policy decisions and committed action to develop best practices to intervene in the aquatic environment for the larger social good will be the result.

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