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Catch and Culture - Environment is published three times a year by the office of the Mekong River Commission Secretariat in Vientiane, Lao PDR, and distributed to over 650 subscribers around the world. The preparation of the newsletter is facilitated by the Environmental Management Division of the MRC. Free email subscriptions are available through the MRC website, www.mrcmekong.org. For information on the cost of hard-copy subscriptions, contact the MRC's Documentation Centre at doc.centre@mrcmekong.org.

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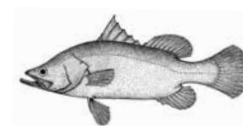


Cover photo: Workers at the National Breeding Centre for Southern Freshwater Aquaculture in Viet Nam transferring a giant barb (*Catlocarpio siamensis*) to a new pond. Weighing about 40 kg, this individual was among 40 broodstock separated from a similar number of isok barb (*Probabarbuis jullieni*) broodstock in November. Based in Cai Be in the Mekong Delta province of Tien Giang, the centre has been collecting giants barb from the wild for breeding purposes since 2005. According to the International Union for the Conservation of Nature (IUCN), the fish is a "critically endangered" species which faces "extremely high risk of extinction in the wild in the immediate future." Known as *ca ho* in Vietnamese, the giant barb can grow to a length of three metres. The fish is native to the Mekong Basin and the Chao Phraya Basin in Thailand.

COVER PHOTO AND THIS PHOTO: CHHUT CHHEANA

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New guidelines for transboundary environmental impact assessments

Developers in Cambodia, Lao PDR, Thailand and Viet Nam now have a new tool to assess the cross-border environmental impacts of projects in the Lower Mekong Basin. The guidelines supplement a framework agreement on water-use and diversion projects that was signed 15 years ago.

The MRC has drafted Guidelines for Transboundary Environmental Impact Assessments in the Lower Mekong Basin. Released on October 2, the guidelines follow legal and institutional reviews and national and regional consultations with Cambodian, Lao, Thai and Vietnamese government officials between 2015 and 2017. An indicative checklist of potential transboundary impacts covers hydropower and irrigation schemes; ports and riverworks; navigation activities; industrial and mining projects; aquaculture; and water-supply projects. According to the guidelines, Cambodia has proposed a minor change in scope to cover “existing and proposed development on the Lower Mekong mainstream.” At the same time, Lao PDR and Thailand have suggested that the draft be considered a “working document” that can be

amended based on practical experience.

In an introduction, the MRC Secretariat says it developed the guidelines with regard to consultations it supported for three existing mainstream hydropower projects at Xayaburi, Don Sahong and Pak Beng in Lao PDR. In addition, the document takes into account lessons learnt from an MRC-commissioned case study on the Sre Pok and Se San rivers in northeast Cambodia and the Central Highlands of Viet Nam. The secretariat says the guidelines also reflect experience with the United Nations Economic Commission for Europe’s Convention on Environmental Impact Assessment in a Transboundary Context, known as the Espoo Convention (see below).

‘Supporting tool’

The new guidelines are a “supporting tool” that can be applied to different systems for environmental impact assessment (EIA) studies in Member Countries. They supplement the MRC’s Procedures for Notification, Prior Consultation and Agreement (PNPCA) for using diverting water from the Mekong, signed by ministers in Phnom Penh in 2003. The guidelines also take into account other

What is the Espoo Convention?

The Espoo Convention sets out the obligations of parties to assess the environmental impact of certain activities at an early stage of planning. It also lays down the general obligation of states to notify and consult each other on all major projects that are likely to have a significant adverse environmental impact across boundaries. The convention was adopted in the Finnish city of Espoo in 1991 and entered into force in 1997. The sixth session of the Meeting of the Parties to the Convention took place in Geneva in 2014.

The first amendment to the convention adopted in 2001 entered into force in 2014, allowing

accession to the agreement by UN Member States that are not members of the United Nations Economic Commission for Europe, a Geneva-based body which has 56 members including in North America and Central Asia as well as Israel. The second amendment in 2004 came into force in 2017. This allows affected parties to take part in scoping, requires compliance reviews, revises a list of activities and makes other minor changes.

Further reading

<https://www.unece.org/environmental-policy/conventions/environmental-assessment/about-us/espoo-convention/enveiaeia/more.html>



Srepok 3 Hydropower Project on the Srepok River in Dak Lak Province in the Central Highlands of Viet Nam. The Srepok flows into the Sesan and Sekong rivers in the Cambodian province of Stung Treng before reaching the Mekong mainstream. The three Mekong tributaries, which span, Cambodia, Lao PDR and Viet Nam, are home to numerous hydropower projects.

PHOTO: MRC

ministerial agreements — Procedures for Data and Information Exchange and Sharing (signed in Bangkok in 2001), Procedures for Water Use Monitoring (signed in Phnom Penh in 2003), Procedures for Maintenance of Flows on the Mainstream (signed in Ho Chi Minh City in 2006) and Procedures for Water Quality (signed in Ho Chi Minh City in 2011).

“Further positive synergy is also expected with the currently evolving Joint Environmental Monitoring of Mekong Mainstream Hydropower Projects,” the secretariat says. Member Countries are urged to apply the MRC’s “evolving policies and practices on public participation” in processes addressed by the guidelines. Principles and provisions — such as those for post-project environmental monitoring — “are also applicable in the context of already existing development projects. As such, Member Countries are invited to apply elements of the

guidelines to the management of “all relevant projects with potential transboundary impacts.”

Objectives

The guidelines aim to support the cooperative objectives and principles of the Mekong Agreement signed by Cambodian, Lao, Thai and Vietnamese ministers in 1995. These are Article 3 (Protection of the Environment and Ecological Balance), Article 5 (Reasonable and Equitable Utilisation), Article 6 (Maintenance of Flows on the Mainstream), Article 7 (Prevention and Cessation of Harmful Effects) and Article 8 (State Responsibility for Damages).

A first specific objective is to support and reinforce the implementation of MRC procedures and use MRC advice on evaluating and managing of common environmental issues of common interest. A second is to support national systems

Who pays for what: countries of origin, proponents and potentially affected countries

Under the guidelines, the country of origin covers the administrative costs of the EIA authority and others involved in transboundary assessments in a “standard manner” as with any domestic assessment. But the costs of taking part in early consultations and formal transboundary consultations — such as travel costs — should be covered by proponents, defined as those who propose, implement or operate a project.



Sluice gates across the Ba Lai River in the maritime Vietnamese province of Ben Tre. The gates can be used to stop saltwater intrusion into Mekong Delta farmlands that rely on freshwater. Ben Tre is a leading producer of coconuts.

PHOTO: MRC

Proponents also cover all costs involved in EIA analyses and reports within a scope defined by the authority in the country of origin granting the final EIA approval. This includes analysing impacts on a potentially affected country such as costs for travel, community consultations and obtaining data. In principle, proponents have to cover the costs for national and the transboundary consultations. In practice, however, “some assistance of the Concerned Member Countries can be sought.”

The guidelines note that the costs of mitigating negative impacts and environmental monitoring “can be substantial and even capable of affecting the overall project economic viability.” In general, the “polluter-pays” principle is the departure point for case-by-case arrangements that “must be concluded before the final decision on the project implementation is made.” In addition, “the Proponent and later the operator of a project shall bear the costs of adjusting the design, or the mode of operation of the project to ensure compliance with the Environmental Management Plan and operation of the

monitoring.”

For public consultations on their territory, countries potentially affected by a project can make in-kind contributions such as buildings for meetings and costs associated with government officials taking part. Such cost-sharing should be an incentive to “maximise efficiency of the consultation process and refrain from stipulating non-standard requirements entailing excessive costs to be borne by the project Proponent.”

The guidelines also provide for MRC covering the costs of independent reviews of EIA reports — provided they’re part of the notification, consultation and agreement procedures adopted in 2003 with support from an MRC task force and other expert groups. The costs of additional national reviews of such EIA reports shall be covered by an affected country “from its own resources”, the document says. But seeking external financial support should be recommended and the MRC Secretariat “shall provide assistance” for such efforts.

for environmental impact assessments by applying them to projects with potential transboundary impacts.

‘The guidelines respect differences in national laws and systems for assessments in each country’

“Economic development projects in the Lower Mekong Basin are already causing concern amongst the Member Countries about their potential transboundary environmental impacts,” the document states. So the guidelines aim to “facilitate MRC cooperation and support the protection of the environment, natural resources, aquatic life and conditions, and the ecological balance of the Lower Mekong River Basin and prevention and cessation of harmful effects” in accordance with the Mekong Agreement.

At the same time, however, the guidelines respect differences in national laws and systems for assessments in each country. Applying their provisions should therefore allow for “meaningful participation” by the countries concerned “without prior harmonising their legislation and procedures to be mutually fully compatible. In this manner the practice and experience can grow, and that in turn will allow for further improvement.”

Technical implementation

The guidelines stipulate how countries of origin, project proponents and potentially affected countries should implement transboundary assessments in nine areas — identifying impacts and screening; initiation and early consultations; scoping; report preparation; regional consultations; public participation, information dissemination and consultation with potentially affected countries; approval and decision-making; results, implementation and monitoring; and costs (see box opposite). The document also offers guidance for institutional support — from the MRC Secretariat and the National Mekong Committees in each country — and provisions for revising the guidelines.

Further reading

<http://www.mrcmekong.org/assets/Publications/TbEIA-Guidelines-Final-version-25-9-2018.pdf>

How significant is ‘significant’?

Under the guidelines, a transboundary assessment has to comply with legislation in the country of a project’s origin where transboundary impacts are considered and where the Environmental Impact Assessment (EIA) is subject to transboundary consultations.

Transboundary impacts are those in the territory of a Member Country that “potentially affect” other Member Countries. These include effects on hydrology and hydraulic regimes, river morphology and sediment, aquatic ecology and biodiversity, water quality, and socio-economic consequences like impacts on cultural heritage, access to natural resources and people’s livelihoods depending on the Mekong — such as fisheries, for example. The guidelines stipulate that “both negative and positive environmental impacts shall be acknowledged.”

But how do stakeholders — any person, group or institution with an interest in a project including “those who are generally excluded from the decision-making process” — distinguish between significant and insignificant impacts? The guidelines offer a definition. “The term ‘significant’ is understood as excluding mere inconveniences or minor disturbances,” the document states. “Member Countries are expected to tolerate from one another, in conformity with the principle of good neighbourliness.”

Such understandings, it says, should be based on relevant international agreements such as the UN Convention on the Law of the Non-Navigational Uses of International Watercourses adopted in 1997 which went into force in 2014. According to the United Nations, the sole MRC Member Country to be a party to the treaty is Viet Nam which acceded to the agreement in 2014 but “reserves the right to choose the appropriate means of dispute settlement notwithstanding the decision of the other party to the concerned dispute.”

Further reading

https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-12&chapter=27&lang=en#1

Impacts of indiscriminate fishing around the Tonle Sap Lake

Higher catches of smaller fish species have been offsetting lower catches of larger species in Southeast Asia's biggest lake over the past 15 years. The good news is that overall fish production has been sustained. But the changing composition of the fish population is a warning that the species-rich Tonle Sap is being affected by heavy indiscriminate fishing pressure.

Human impacts like fishing have changed food-web composition and fish-body size in marine waters. But the status of fisheries in important tropical inland waters is largely unknown. Limited evidence suggests declining catches, especially in Asia and Africa where fish protein is of paramount importance to food security. A report published by the journal *Scientific Reports* in June looks for signs of human impacts from indiscriminate fishing around the Tonle Sap Lake in Cambodia which supports one of the world's largest freshwater fisheries.

Amazing amount of gear

But what exactly is indiscriminate fishing? The paper — by scientists from the Cambodian Fisheries Administration, Université Paul Sabatier in France, the MRC Secretariat and the University of Guelph and University of Toronto in Canada — note that the Tonle Sap fishery employs an “amazing” amount of fishing gear. These different types of gear are “applied broadly across habitats and seasons in a manner that uniformly catches a high diversity of fishes,” the paper says. “This approach is highly suggestive of a relatively indiscriminate fishery.”

To assess the impact of such indiscriminate fishing, the scientists analysed catches of 116 species from the industrial-scale *dai* fishery on the Tonle Sap River in northern Phnom Penh between the 2000–01 and 2014–15 seasons. The fishery involves stationary bagnetts in rows across the river at the end of the wet season as fish migrate out of the Tonle Sap Lake into the Mekong. In collaboration with the MRC, the Cambodian

Fisheries Administration has been monitoring this fishery since 1995.

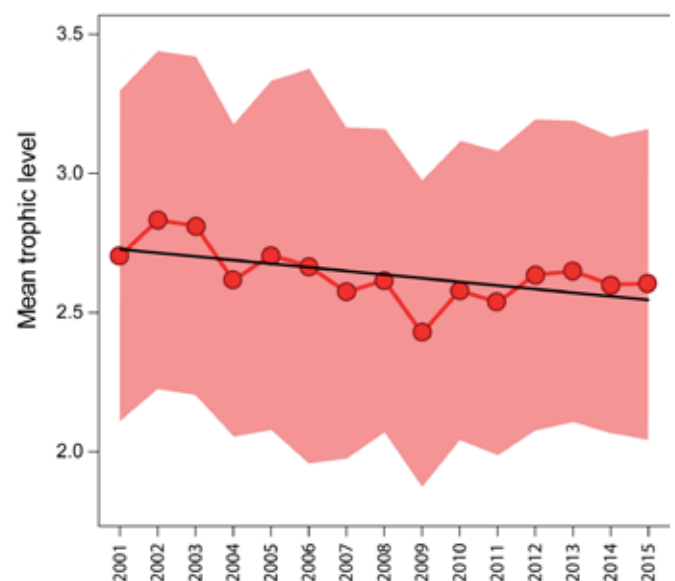
The analysis showed decreasing catches for 78 percent of the species over the 15-year period. Downward trends in catches mainly affected medium to large-bodied species. These tend to occupy high trophic levels that are closer to the top of the food chain (see box opposite). The analysis also indicated a relatively stable or increasing trend in catches of small-sized species. In addition, it showed decreases in individual fish weights and lengths for several common species.

‘Warning signal’

With higher catches of smaller species compensating for lower catches of larger species, the overall fish catch has remained “remarkably resilient” over the past 15 years, the paper says. “Our finding of sustained production but altered community composition is consistent with predictions from recent indiscriminate theory, and gives a warning signal to fisheries managers and conservationists that the species-rich Tonle Sap is being affected by heavy indiscriminate fishing pressure.”

Average trophic level

From 2000-01 season to 2014-15 season



SOURCE: NGOR ET AL. (2018)

Trophic levels

The trophic level of an organism is the average number of steps in the food chain. The trophic level of fish or other animals may be inferred from anatomy and examining stomach contents. According to MRC Technical Paper No 47, many Mekong fish species eat some plant material but most consume other foods if available. The most important species in river-floodplain fisheries are herbivores such as algae-feeding carps and omnivores including most cyprinids and pangasiid catfishes. Catches from swamps and rice fields are typically dominated by carnivores such as snakeheads and walking catfishes.

Local ecological knowledge can identify primary production sources such as plants but cannot clarify contributions of different kinds of foods. A technique known as stable isotope analysis is increasingly being used to calculate trophic levels by estimating how much different types of primary production — such as algae, grasses and higher terrestrial plants — contribute to the biomass of an organism.

A study of a pond in the Mekong system found

a maximum of four steps for the animals at the highest level, swamp eels and snakes (Kupfer *et al.*, 2006). In Thailand, studies have shown that the weighted average trophic level of all species in catches was 2.6 in Ubolratana Reservoir in the Mekong Basin and 2.4 in Pasak Prolasid Reservoir in the Chao Phraya Basin (Thapanand *et al.*, 2009). The average mainly depended on direct consumption of vegetation, principally phytoplankton or detritus.

Further reading

Hortle, K.G. and Bamrungrach, P. (2015) Fisheries Habitat and Yield in the Lower Mekong Basin. MRC Technical Paper No. 47. Mekong River Commission, Phnom Penh.

Kupfer, A.; Langel, R.; Scheu, S.; Himstedt, W. and Maraun, M. (2006) Trophic ecology of a tropical aquatic and terrestrial food web : insights from stable isotopes (15N). *Journal of Tropical Ecology*, 22: 469-476.

Thapanand, T.; Jutagate, T.; Wongrat, P.; Lekcholayut, T.; Meksumpun, C.; Janekitkarn, S.; Rodloi, A.; Moreau, J. and Wongrat, L. (2009) Trophic relationships and ecosystem characteristics in a newly-impounded man-made lake in Thailand. *Fisheries Management and Ecology*, 16: 77-87.

Simplified aquatic food chain

Trophic Class	Functional Group	Example Species
5	Top predator	Humans
4	Tertiary consumer	Large fish (e.g. snakeheads, walking catfishes)
3	Secondary consumer	Small fish (e.g. small carps)
2	Primary consumer	Zooplankton (e.g. insects, shrimps)
1	Primary producer	Phytoplankton (e.g. leaves, detritus)

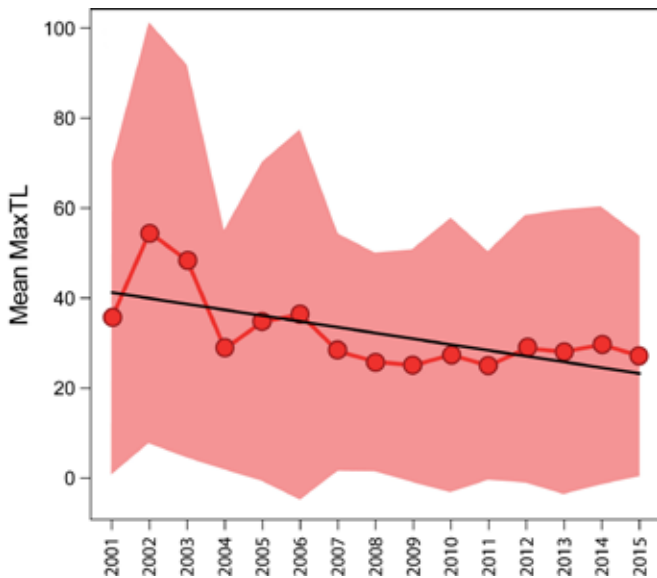
Source: Adapted from Hortle and Bamrungrach (2015)

Among larger species, the paper notes that the Mekong giant catfish (*Pangasianodon gigas*) “has almost disappeared from the Mekong River System” with the Tonle Sap River one of the last places where a few individuals are still sometimes caught. Likewise, the Mekong giant carp (*Catlocarpio siamensis*) “was seen regularly in the catch of 1938–39 and 1962–63. Nowadays, however, the Mekong giant carp has also become critically endangered.” According to the Red List of Threatened Species published by the International

Union for the Conservation of Natures (IUCN), that means these two species face an “extremely high risk” of extinction in the wild in the “immediate” future. Similarly, the Laotian shad (*Tenulosa thibaudeaui*) “was still relatively abundant in the Dai catch in 1938–39 and 1962–63 and used to be one of the most important species. Nonetheless, it too has been experiencing drastic decline during the last two decades.” IUCN considers this fish to be vulnerable with a “high risk” of extinction in the wild in the “medium-term” future.

Average total length

From 2000-01 season to 2014-15 season



SOURCE: NGOR ET AL. (2018)

The list goes on. Isok barb (*Probarbus jullieni*) was “comparatively scarce” for at least 65 years in Thailand. But this species and the thick-lipped barb (*Probarbus labeamajor*) “were later observed

to be very abundant” in the southern Laos and northern Cambodia in the 1970s when the region was at war. Both have declined, particularly since the 1990s, and these two species are now considered endangered, with a “very high risk” of extinction in the wild in the “near” future. Other formerly-common and high-value species, including the small-scale mud carp (*Cirrhinus microlepis*) are vulnerable.

According to the authors, declining catches of giant and larger-bodied species is probably linked to their growing slowly and maturing late — around seven years in the case of the giant catfish and giant carp. “These larger species often require large geographical ranges to complete their life cycles and undertake long migrations between critical habitats, making them more susceptible to capture before their first reproductive event. Given the increasing fishing pressure in the region, overfishing seems a likely cause of the decline observed in giant, large and medium-sized fishes in the Tonle Sap,” the paper says. It notes that this is consistent with declines in long-lived, late-spawning freshwater fish stocks such as the

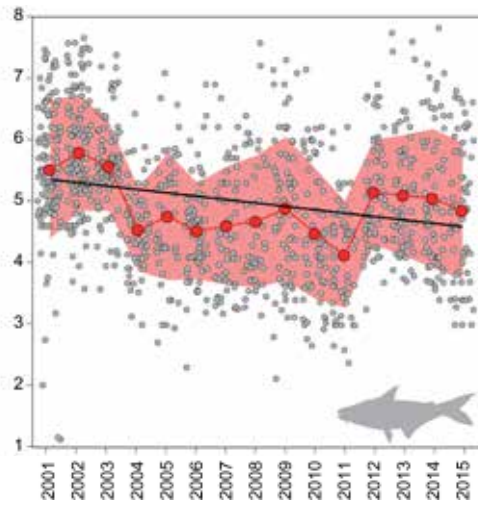


Small-scale mud carp (*Cirrhinus microlepis*)

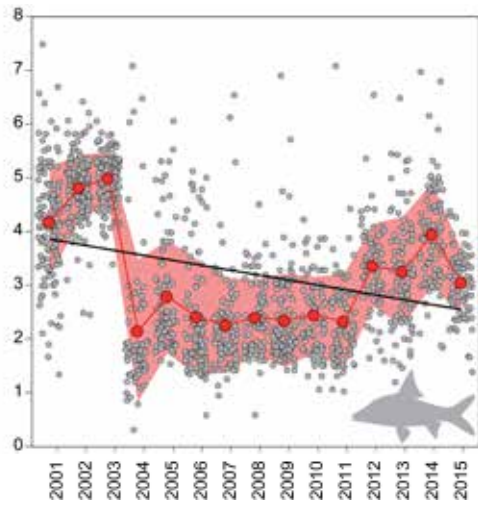
PHOTO: LEM CHAMNAP

Large species
Striped catfish (*Pangasianodon hypophthalmus*)

Mean weight of individual fishes (log-transformed)

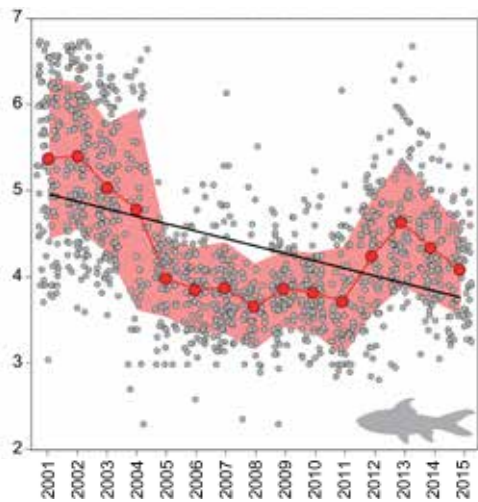


Trey chkok (*Cyclocheilichthys enoplos*)

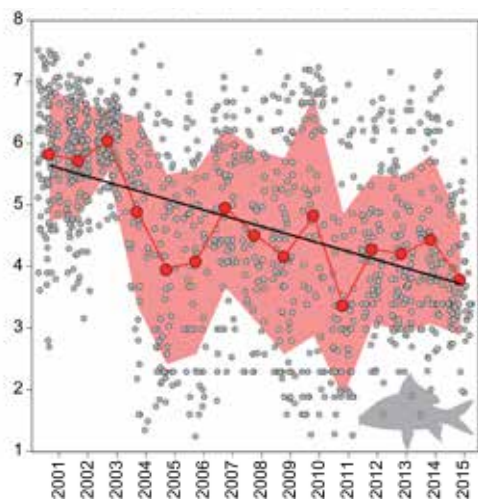


Medium-sized species
Small-scale mud carp (*Cirrhinus microlepis*)

Mean weight of individual fishes (log-transformed)

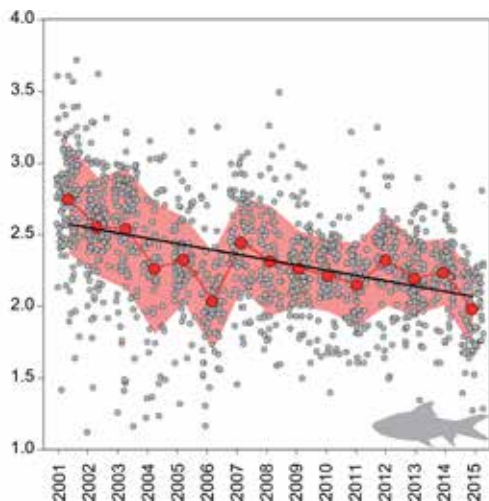


Giant bony-lip barb (*Osteochilus melanopleurus*)

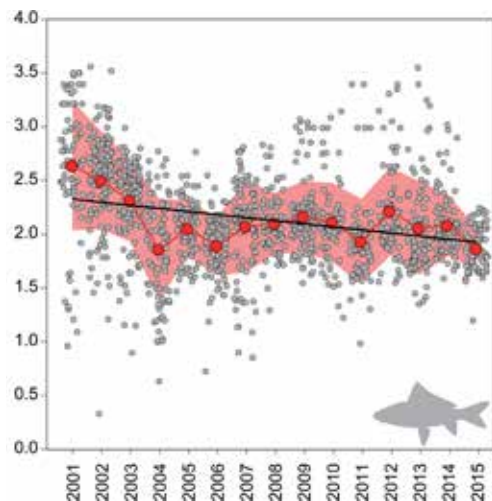


Small species
Lesser silver mud carp (*Henicorhynchus lobatus*)

Mean weight of individual fishes (log-transformed)



Labiobarbus lineatus



SOURCE: NGOR ET AL. (2018)

Murray cod (*Maccullochella peelii*) in Australia and about 20 sturgeons across Asia, Europe and America as well as the pirarucu (*Arapaima gigas*) in Amazon.

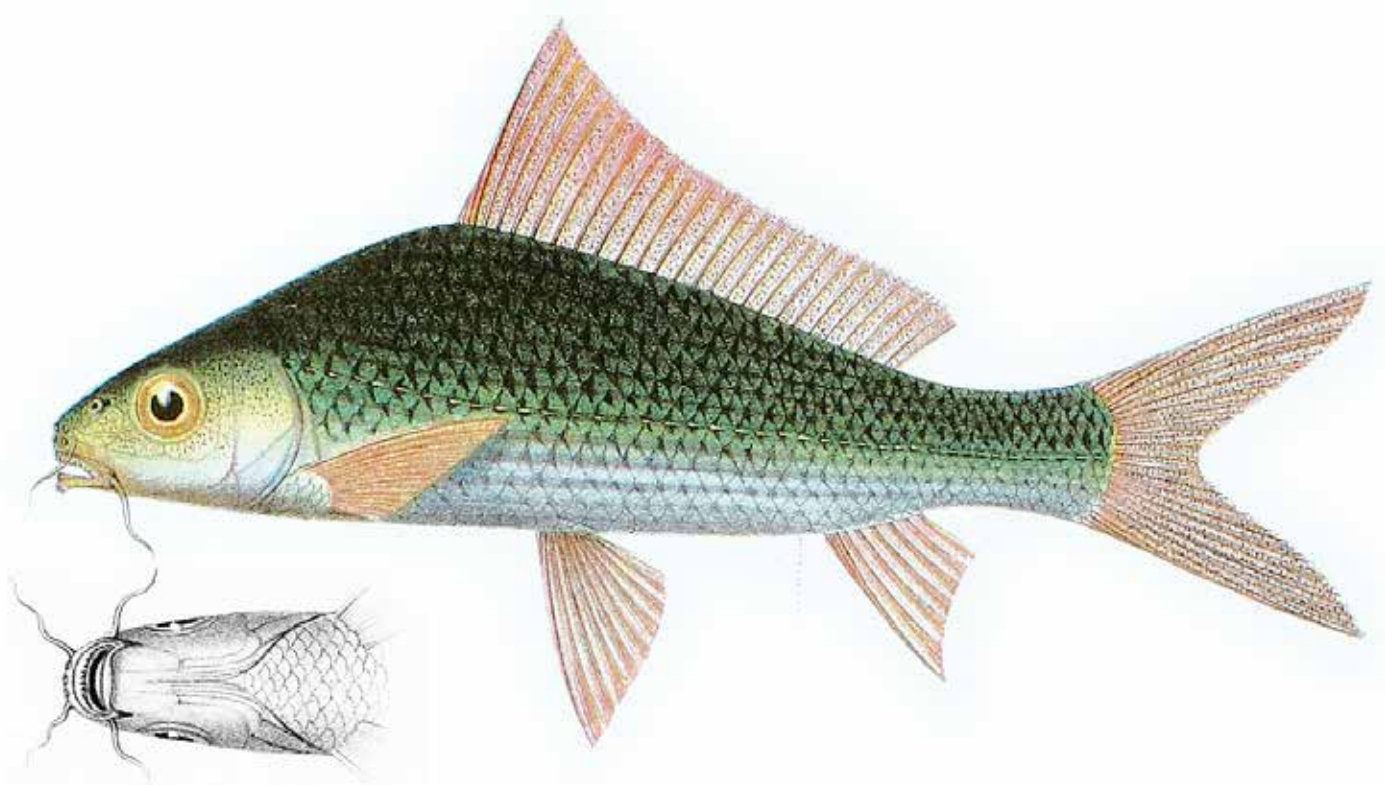
What about smaller fishes? The paper says catches of species from the *Labiobarbus* genus increased “significantly” over the study period. For instance, members of the genus accounted for about 5 percent of *dai* catches between 1995 and 2000, rising to 19 percent in the 2013/14 season. As for fishes in the *Henicorhynchus* genus of carps, they made up 25 percent of the *dai* catch weight in 1962/63. But their share rose to 40 percent between 1995 and 2000 and 43 percent in the 2013/14 season. “Comparable increasing trends are also manifested for other small-sized cyprinids that are likely more robust to fishing pressure and also reproduce quickly on the vast area of seasonal flooded land every year once predatory pressures of higher trophic level fish are reduced,” the paper says.

But the paper also notes that catches of some smaller species have also been declining. “These species feed in higher trophic levels (3.4–3.7) than

some giant and large-sized species such as the Mekong giant catfish (2.3) and Mekong giant carp (2.92) which are detritus and algae feeders,” it says. “It is likely that further research on individual life history traits may help shed light on reasons of the decline, which is warranted because overfishing is not be the only threat to the Tonle Sap’s fishes.”

‘Wall of death’

Overfishing reflects increased efficiency of fishing gear and rapid population growth. The paper blames the use of monofilament nylon gillnets for declining catches of small-scale mud carp, Laotian shad and Probarbus species as well as striped catfish (*Pangasianodon hypophthalmus*), wallago (*Wallago leeri*) and Irrawaddy dolphins (*Orcaella brevitostris*). Such gillnets are considered a “wall-of-death” for many migrating fishes. “The problems caused by these fishing techniques have likely been exacerbated by population growth,” the paper says. “The population of countries sharing the Lower Mekong Basin has increased about threefold between 1960 and 2015. Similarly, the Cambodia population has also grown almost threefold with about 85 percent rural dwellers.



Labiobarbus leptocheilus, known as *trey khnawng veng* in Khmer

ILLUSTRATION: PIETER BLEEKER/ACTA SOCIETAS SCIENTIARUM INDO-NEERLANDICAE

Since entry into fishing is free, and fishing gears are very affordable, a combination of forces including rising population along with the lack of other livelihood options, has resulted in millions of people moving into the fishing sector thereby increasing fishing effort and pressure on fish stocks.”

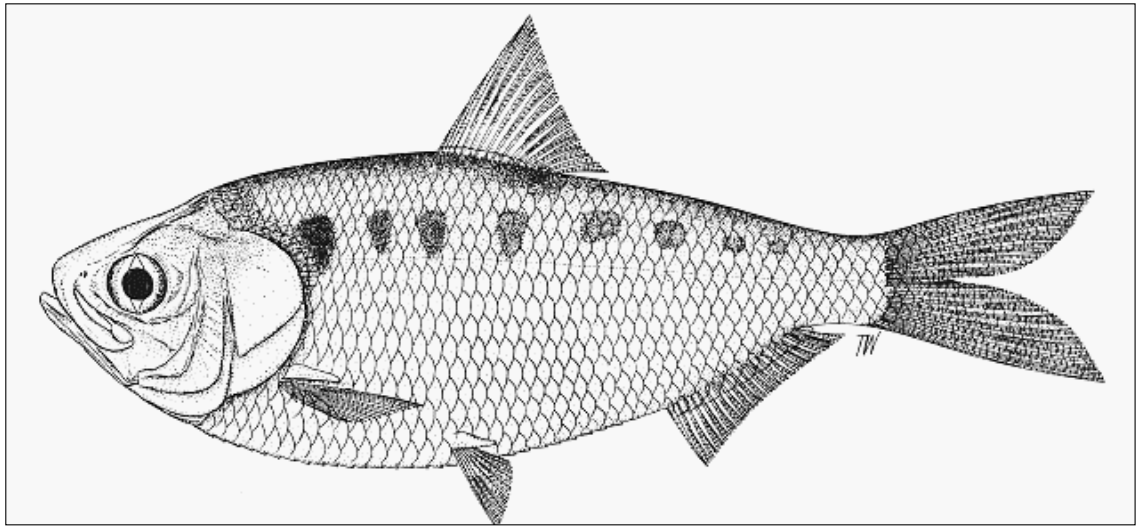
Hydropower development meanwhile poses an “increasingly large additional threat” to Mekong fisheries. “Numerous hydropower developments loom over the Mekong Basin threatening to alter flows, fragment habitats, block fish migration routes from completing life cycles, degrade water quality and reduce the overall productivity of rivers resulting from nutrients and sediment losses,” the paper says. “This is particularly troubling because the migratory species present in the Tonle Sap represent a third of the total number of fish species in the Mekong Basin from which some 877 fish species have been recorded.”

The authors conclude that “the species-rich Tonle Sap, so far able to maintain total harvest levels, may be close to its limit. The findings suggest that enhanced protection and conservation efforts are urgently needed to maintain food security in this region.” They note that institutions for fisheries protection and conservation in Cambodia are now in place with restrictions on fishing seasons and different types of fishing gear as well as fish sanctuaries. What’s needed now is “sufficient resource allocation” to enforce and monitor regulations to protect and conserve Tonle Sap fish biodiversity. The main aim would be to let fish spawn — at least once before being caught — while allowing fish to grow and the “mega-

spawners” to live.

Conservation priority

Regulations based on peak seasonal migrations to allow some fishes to pass through the Tonle Sap River would let some juveniles and broodfishes to complete their life cycles — accessing floodplains around the Tonle Sap and downstream from Phnom Penh to feed, and swimming to upstream



Laotian shad (*Tenuulosa thibaudeaui*)

ILLUSTRATION: FAO

stretches of the Mekong and tributaries to seek dry-season refuge and breed. The authors note that 516 community fisheries have been set up in Cambodia including 228 in the Tonle Sap floodplains. So conservation priority should be given to the community fisheries in these key critical fish habitats. “By effectively protecting and conserving these areas combined with appropriate hydraulic conditions, some juveniles and broodfishes may be maintained to sustain the seasonal reproduction, recruitment and growth,” they conclude. “For future work, it is worth exploring a modelling approach which is able to suggest a management strategy that maximizes the present benefits from the Tonle Sap fishery while maintaining its long-term sustainability.”

Further reading

Ngor P.B, K.S. McCann, G. Grenouillet, S. Nam, B.C. McMeans, E. Fraser and S. Lek (2018) Evidence of indiscriminate fishing effects in one of the world’s largest inland fisheries. *Scientific Reports*, 8:8947.

Cambodia's water snake trade — not just crocodile feed and skins but also snacks

By CHHUT CHHEANA

Snack foods processed from water snakes native to the Tonle Sap Lake seem to be growing in popularity among urban Cambodians, who are prepared to pay a much as \$25 a kilogram to roadside vendors. But with recent fires in flooded forests around the lake putting upward pressure on prices, will consumer interest last?

The Tonle Sap Lake is generally well known as Southeast Asia's biggest lake and for having one of the most productive fisheries on the planet. The Cambodian lake is less known for having the world's largest harvest of water snakes including one that's endemic to the lake — the Tonle Sap water snake (*Enhydris longicauda*), known as pous ph'ak in Khmer (see box on page 19). Seven main species have been identified in the catch (see

table on page 20). The snakes are mostly used as feed by crocodile farmers. Bigger ones end up in the skin trade as belts or wallets, especially larger individuals of the banded swamp snake (*Homalopsis buccata*) and Bocourt's water snake (*Enhydris bocourti*). The rest are processed into snack food, which seems to be getting increasingly popular among people in urban areas.

Din Yim buys water snakes from fishermen on the the lake, where she lives in a floating house in Kampong Luong, a commune in Krakor District in Pursat Province. Her husband and two sons also end up with snake bycatch in their nets while fishing on the lake.

The 48-year-old snake processor buys live water snakes for KHR 3,500 (\$0.85) to KHR 4,000



Bocourt's water snake (*Enhydris bocourti*), one of the seven main water snake species caught around the Tonle Sap

PHOTO: JOHN MURPHY [HTTPS://WWW.FLICKR.COM/PHOTOS/76407130@N05/6887034498](https://www.flickr.com/photos/76407130@N05/6887034498)



Din Yim displays dried water snake ready for sale at her home with a grandson in the floating village of Kampong Luong in Pursat Province in August. At a local market, she says a kilogram of dried snake usually wholesales for around KHR 55,000 (\$13.75). But if she retails the snake directly to consumers as a roadside vendor nearby, Din Yim says she can earn KHR 100,000 (\$25) a kilogram.

PHOTO: CHHUT CHHEANA

(\$1.00) a kilogram and dead ones for KHR 3,000 (\$0.75). She fillets the snakes after draining their blood and removing the skins, which are later boiled and used as fish feed. She then mixes the flesh with various ingredients and stores the fillets in a container overnight before drying the snakes in the sun the next day. To make a kilogram of snacks, she needs about 10 or 12 kilograms of snakes.

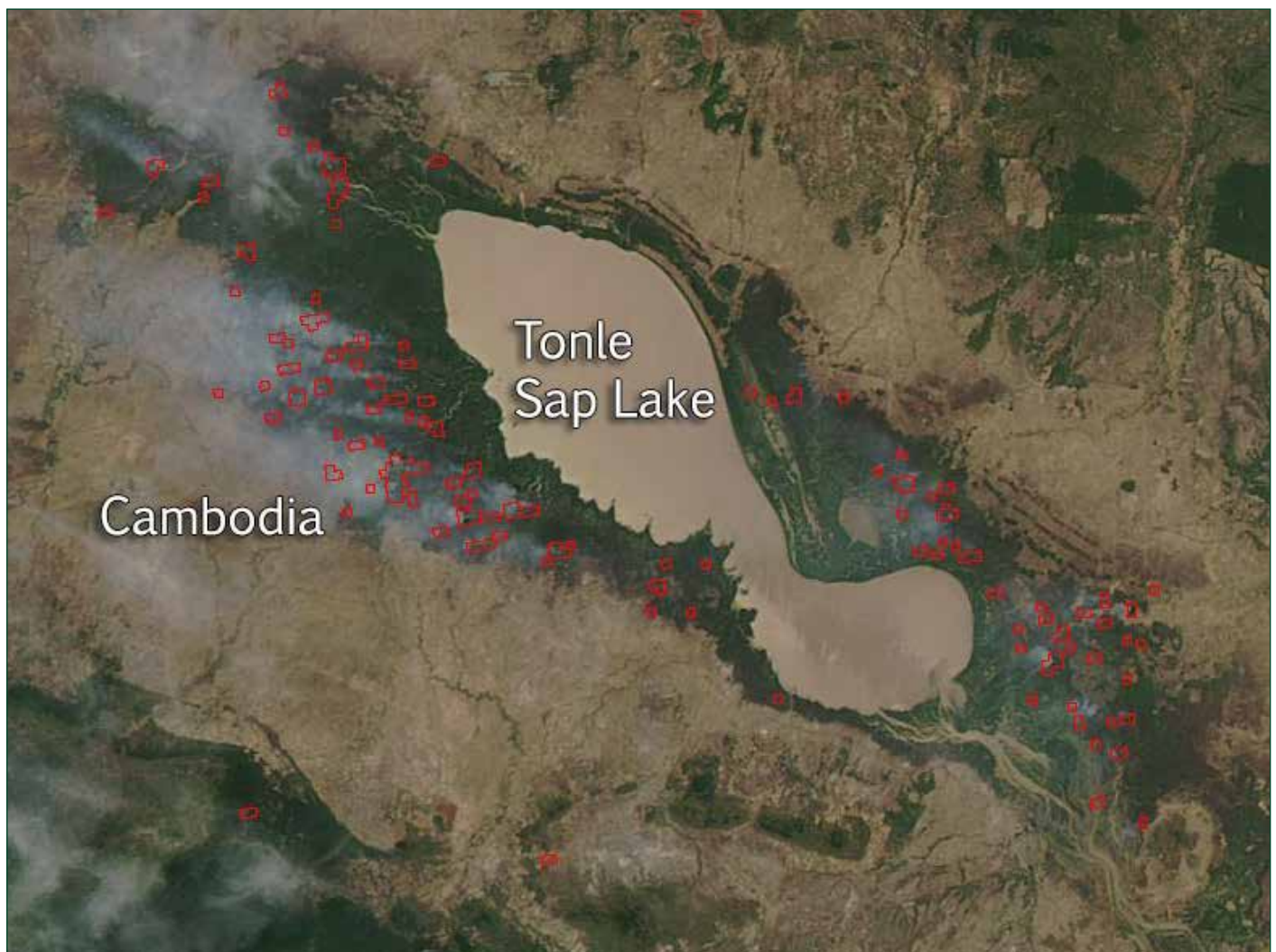
Din Yim distributes her snakes to snack-food vendors at a local market about four kilometres from her float in village, known as Kampong Lor. She usually charges about KHR 55,000 riel (\$13.75) a kilogram but can earn almost twice as much as a roadside vendor on the highway between Phnom Penh and Battambang. "If I take them to sell myself along National Road No. 5,

they would cost up to 100,000," she says. At that price, dried snake commands a similar price to high-quality dried fish sold at roadside stalls.

Most of the snakes Din Yim buys are small. "More than 100 water snakes weigh only a kilogram," she says. "If the water snakes are large, especially in the wet season when they have a lot of food, 100 snakes can weigh up to 1.5 kilograms." She says fishermen usually land between 100 and 200 snakes a day but that catches can be as high 500 individuals in the peak season.

Declining catches

The prices Din Yim pays fishermen for live snakes is as as much as four times higher than they were between 2004 and 2006, according to a study published in 2010. She blames declines in snake



Fires around the Tonle Sap are shown in a natural-color satellite image acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the NASA's Aqua satellite on April 15, 2015

NASA IMAGE: JEFF SCHMALTZ, MODIS RAPID RESPONSE TEAM



Red-tailed pipe snake (*Cylindrophis ruffus*)

PHOTO: WIBOWO DJATMIKO

numbers on fires affecting the flooded forests around the Tonle Sap Lake. “Catches of all types of water snake have declined over the past 20 years,” she says. Din Yim says the declines have been drastic this year with fires burning in flooded forest areas during the dry season, which runs from October to April.

In 2016, when an extreme drought caused Tonle Sap water levels to drop to record lows, fires raged around the lake. According to the International Union for the Conservation of Nature (IUCN), the fires were driven by two factors. The first is accidental — using smoke to harvest honey, burning firewood and leaving cooking fires unattended. The second is intentional — burning flooded forests to convert them to ricefields, hunt animals or set long fishing nets across river channels.

“Forest fires are a main threat to the flooded forest,” IUCN said in a statement released in mid-2016, adding that the loss of flooded forest would lead to declines in fish and waterbird populations.

World’s biggest snake harvest

A study published in *Biological Conservation* in 2007 found that an estimated 6.9 million water snakes (777 tonnes) of seven species were being harvested from the Tonle Sap Lake every year — representing the world’s largest exploitation of any snake assemblage. In 2010, a subsequent study in the same journal noted that the domestic market for snakes was mainly for crocodile food

Endemic species considered vulnerable

The Tonle Sap water snake (*Enhydryis longicauda*) is known as “pous ph’ak” in Khmer after a type of fermented dish made from fish, salt, rice and galangal. According to IUCN, a group based in Switzerland, the species is endemic to the waters and surrounding wetlands of the lake and distributed across an area of about 17,000 square kilometres. In an conservation assessment published in 2010, IUCN said the species had a high risk of becoming extinct in the wild in the medium term.

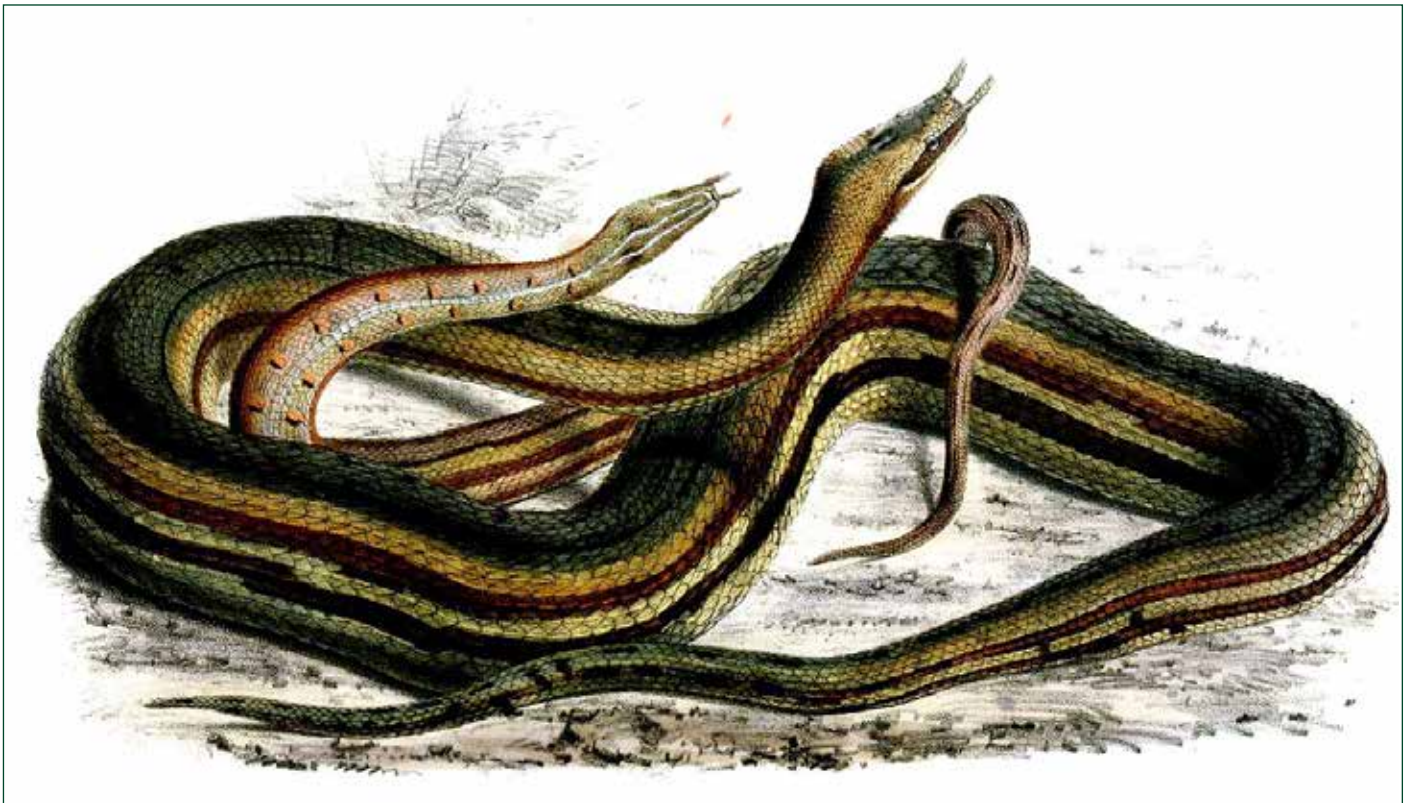
“It is heavily exploited for crocodile food and for human consumption and the population has already declined significantly due to over-harvesting,” the assessment said. “There is also degradation in the quality of the habitat. Conservation measures are needed to ensure that this species does not become even more threatened in the future. Further research into the harvest levels and monitoring is needed to ensure this species does not trigger a higher threat category.”

According to scientists IUCN who did the assessment, including the lead author of the two studies on the lake’s snake harvest, the species lives in muddy shallow waters and feeds on fish. It may leave the water on rare occasions. It is not clear whether it moves with seasonal changes in the lake’s water level. Nor is it clear whether it buries itself in mud during the dry season.



Tonle Sap water snake (*Enhydryis longicauda*)

PHOTO: JOHN MURPHY ([HTTPS://WWW.FLICKR.COM/PHOTOS/76407130@N05/8373153683](https://www.flickr.com/photos/76407130@N05/8373153683))



A 19th century illustration of tentacled snakes (*Erpeton tentaculatus*). According to the study published in 2007, this species and the Tonle Sap water snake (*Enhydris longicauda*) showed the greatest overlap between reproduction and hunting mortality in the Tonle Sap Lake as most trade in these species took place during the second peak in hunting just before their reproductive seasons. The Red List of Threatened Species of the International Union for the Conservation of Nature (IUCN) considers the Tonle Sap water snake as “vulnerable” (high risk of extinction in the wild in the medium term). The tentacled snake and the other five species are considered to be of least concern.

ILLUSTRATION: G.H. FORD/ZOOLOGICAL SOCIETY OF LONDON

Largest exploitation of any snake assemblage

English name	Khmer name	Scientific name
Rainbow mud snake	Pous proloeut (water lily snake)	<i>Enhydris enhydris</i>
Tonle Sap water snake	Pous ph'ak (fermented fish snake)	<i>Enhydris longicauda</i>
Banded swamp snake	Pous Trey (fish snake)	<i>Homalopsis buccata</i>
Bocourt's water snake	Pous chan lamom (Chan Lamom snake)	<i>Enhydris bocourti</i>
Tentacled snake	Pous chhoeu (wood snake)	<i>Erpeton tentaculatus</i>
Checkered keelback	Pous somlap kongkep (frog-killing snake)	<i>Xenochrophis piscator</i>
Red-tailed pipe snake	Pous pleung (fire snake)	<i>Cylindrophis ruffus</i>

Source: Brooks *et al.* (2007) and Cambodian Fisheries Administration Diary (2011)

but that live and fresher snakes were used by humans, primarily as snack food.

The port of Chong Khneas in Siem Reap Province accounted for half the landings, with daily trading volumes sometimes approaching 40,000 snakes a day between mid-2004 and early 2008. Prices of live snakes for human food were found to range from about \$0.25 to \$0.80 a kilogram during the

same period and were slightly higher than snakes used as crocodile food. Between 2004 and 2007, snake landings were valued at around \$220,000 a year.

According to the second study, sales of snakes as human food were “more common in the south of the lake where there are fewer crocodile farms” although snakes are not typically a major source



A water snake trader in Kampong Luong floating village on the Tonle Sap Lake in Pursat Province in August. The trader says he buys these snakes and other aquatic animals including turtles to transfer live to Phnom Penh by road. The final destination was not clear. In nearby Kampong Chhnang on the Tonle Sap River, traders have traditionally kept a highly-prized fish known as marbled goby (*Oxyeleotris marmorata*) in cages under their floating houses. The fish are transported to Phnom Penh and flown live to destinations such as Hong Kong and Singapore for consumption in fancy Chinese restaurants.

PHOTO: CHHUT CHHEANA

of people's protein in the area. "This is principally a snack food market," the authors wrote. A major trader in Chong Khneas reportedly said that "demand for snakes as human food is too small to be worth trading if the demand from crocodile farms crashed.

"However, two traders informed us that human consumption of snakes was increasing and we encountered new traders travelling to the lake from other provinces to collect snakes for sale as human food in upland urban areas. According to one of the main snake traders in this area, people only started to come from other provinces to buy snakes to sell as human food in 2003 ... Human consumption of snakes may therefore become

more substantial in the future."

The study noted that the price of snakes sold as a snack food was also likely to be subject to the price of alternative snacks such as fish, birds, insects and packaged snack foods.

Further reading

Brooks, S.E., Allison, E.H., Reynolds, J.D. (2007) Vulnerability of Cambodian water snakes: initial assessment of the impact of hunting at Tonle Sap Lake. *Biological Conservation* 139, 401–414.

Brooks, S.E., Allison, E.H., Gill, J.A., Reynolds, J.D. (2010) Snake prices and crocodile appetites: Aquatic wildlife supply and demand on Tonle Sap Lake, Cambodia. *Biological Conservation* 143, 2127–2135.

'Green Mekong' among new pillars outlined at Tenth Mekong-Japan Summit

Mekong countries and Japan agree to address disaster risk and climate change as well as water issues as part of a new strategic partnership. They also agree to improve waste management and conserve fishery resources

Leaders of five Mekong countries and Japan have adopted a new cooperation strategy with three new pillars including the realisation of a Green Mekong and further collaboration with the MRC to address water-related issues in the basin. The adoption of the Tokyo Strategy 2018 for Mekong-Japan Cooperation came during the Tenth Mekong-Japan Summit hosted by Prime Minister Shinzo Abe in Tokyo on October 9 at which the six leaders agreed to upgrade cooperation to a "strategic partnership" level. The Mekong countries were represented by Cambodian Prime Minister Samdech Hun Sen, Lao Prime Minister Thongloun Sisoulith, Myanmar State Councillor Aung San Suu Kyi, Thai Prime Minister Prayut Chan-o-cha and Vietnamese Prime Minister Nguyen Xuan Phuc.

Under a joint statement adopted by the six leaders, achieving a Green Mekong would include countermeasures against climate change and aquatic pollution along with water resource management and disaster risk reduction. It added that a Green Mekong was a "common goal for the Mekong countries and Japan" and also an "essential factor in realising the Sustainable Development Goals" adopted by United Nations members in 2015

Quality infrastructure

"Realising economic prosperity with a focus on protecting Mekong's beautiful and clean environment is our responsibility for future generations," the statement said. Mekong countries appreciated Japan's continued support under the ASEAN-Japan Environmental Cooperation Initiative including the development of "quality environmental infrastructure" addressing waste management, sustainable cities and wastewater treatment as well as aquatic pollution, chemicals, biodiversity and climate change. The statement said Leaders welcomed the continued commitment and readiness of Japan and Thailand to co-host a Green Mekong Forum. "Leaders also encouraged greater participation of the Mekong region's young generations in the Green Mekong Forum to share their vision and perspective to realise the Green Mekong," it said.



Japanese Prime Minister Shinzo Abe addressing a welcome dinner for the five Mekong leaders in Tokyo on October 9. Mr Abe described the occasion as a "monumental milestone" in the relationship between Japan and the Mekong region, adding that he was "looking forward to your continued cooperation toward the further development of this relationship."

PHOTO: PRIME MINISTER'S OFFICE, JAPAN

Climate change

Leaders vowed to tackle the prevention and reduction of disaster risks, which could impede sustainable development in the Mekong region. “Recognising the current situation where climate change could pose a serious threat to international community including the Mekong region, and cause serious disasters, Leaders reaffirmed their efforts to strengthen the response capability and to work together to tackle climate change in this region, and reiterate our strong commitment to fully implementing the Paris Agreement,” the statement said. “The inclusion of ecosystem-based disaster risk reduction can be effective and sustainable in reducing disaster risk and climate change mitigation and adaptation.” In this context, Leaders decided to advance a Joint Crediting Mechanism.

Water resources

With regard to water resource management, “Leaders stressed the importance of sustainable use and management of water resources and pledged their commitment to further collaborating with regional and international organisations, in particular the Mekong River Commission to address the water related issues in the Mekong River Basin including trans-boundary water resources management.” The statement said the Leaders also stressed the need to coordinate with the US-led Lower Mekong Initiative. Leaders also affirmed plans to strengthen cooperation in “circular economy” approaches based on reducing, reusing and recycling along with “environmentally sound waste management” to assure healthy lives while solving urban problems and aquatic pollution. In addition, “Leaders affirmed the importance of sustainable use of aquatic fishery resources, including cetaceans, based on scientific evidence,” the statement said.

Other pillars

The other two new pillars of Mekong-Japan Cooperation outlined at the summit were “vibrant and effective” hard, soft and industrial connectivity and “people-centred” approaches towards human resource, development, healthcare, education as well as legal and judicial cooperation. In the field of hard connectivity, Leaders reaffirmed the importance of promoting international standards of “quality infrastructure” development such as openness, transparency, economic viability, social and environmental considerations, and the financial soundness of recipient countries.

“Leaders underscored the importance of enhancing energy infrastructure interconnection including through considering an eco-friendly, economical and stable power supplying system,” the statement said. “Recognising the potential and significance of infrastructure development and the promotion of public-private partnership, Leaders welcomed the participation from private sector in this regard.”

Asia’s new value-chain hub

Mekong leaders expressed confidence in the region emerging as a new value-chain hub for Asia at a forum with the Japanese business community following their summit with Prime Minister Shinzo Abe in Tokyo on October 9.

During the Mekong-Japan Business Forum, Vietnamese Prime Minister Nguyen Xuan Phuc reportedly put priority on attracting high-tech investment in developing transport infrastructure, energy, manufacturing, agriculture, finance and banking along with high-quality healthcare. “The Vietnamese Government gives priority to the quality of investment projects instead of quantity,” he was quoted as saying by the Vietnam News Agency (VNA).

In a separate address, Cambodian Prime Minister Samdech Hun Sen noted the “growing interest, support and attention of the Japanese business community towards our dynamic region.” The 10-member Association of Southeast Asian Nations (ASEAN) is becoming the “Factory of Asia,” he said. At the same time, “since the establishment of the ASEAN Economic Community at the end of 2015, the Mekong countries have become even more integrated and connected. And we are now on the verge of transforming the region into the ‘Factory of Southeast Asia’.”

The forum was organised by the Japan External Trade Organization (JETRO) and a ministerial-level consultative body between ASEAN Economic Ministers (AEM) and the Japanese Ministry of Economy, Trade and Industry (METI) known as the AEM-METI Economic and Industrial Cooperation Committee (AMEICC).

How terrestrial ecosystems could shift under different climate change scenarios

In the Lower Mekong Basin, shifting bioclimatic conditions are projected to affect higher elevation mountainous regions in northern Lao PDR, Thailand and Viet Nam in particular over the next four decades. Depending on the scenario, big shifts are also expected for mangroves in the Mekong Delta in Viet Nam and the Cardamom Mountains in western Cambodia.

In assessing the impacts of climate change on water and related resources in the Lower Mekong Basin, the MRC analysed various projections for bioclimatic indicators. The aim was to assess the expected impacts of climate change on the spatial distribution of bioclimatic conditions — particularly on the spatial shifting of bioclimatic zones within ecological regions, also known as ecoregions.

Modelling was used to understand the nature and magnitude of projected changes in the distribution of bioclimatic conditions by 2030 and 2060 — and their potential impacts on terrestrial ecosystems, biodiversity, agricultural production and pastoral systems. The analysis included three global emissions scenarios from the four Representative Concentration Pathway (RCP) trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) in Copenhagen in 2014. The three scenarios are for low emissions (RCP 2.6), medium emissions (RCP 4.5) and high emissions (RCP 8.5).

A report on the analysis indicates a “fairly quick and drastic change” in the distribution of bioclimatic conditions across northern and mountainous parts of the basin. For 2030, “significant warming and generally modestly wetter conditions” are forecast. By 2060, this general trend is projected to have “substantially” increased.

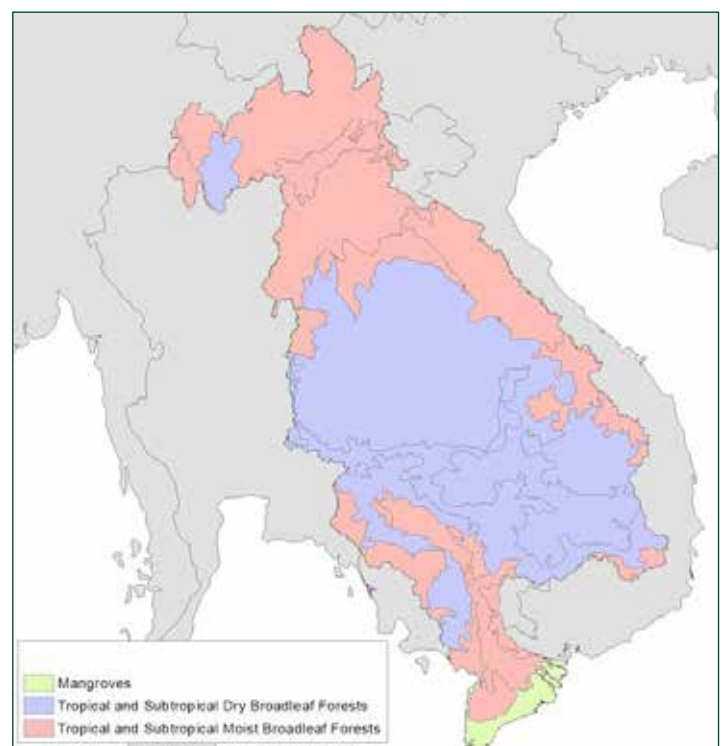
“Results indicate significant and increasing climatic and biological perturbation for biodiversity, ecosystems ... and ecosystem services, and agricultural and pastoral production systems, in

the near to medium-term future under all but the most optimistic scenarios,” the report says. “The magnitude of the predicted change indicated by our analysis points to a prolonged period of profound impacts on terrestrial ecosystems, biodiversity, and ecosystem services across southeast Asia. This should be evident by the year 2030, and well under way by 2060 as a result of warming and climate disruption, and the shifting of bioclimatic conditions spatially, particularly in higher elevation mountainous regions.”

What are ecoregions?

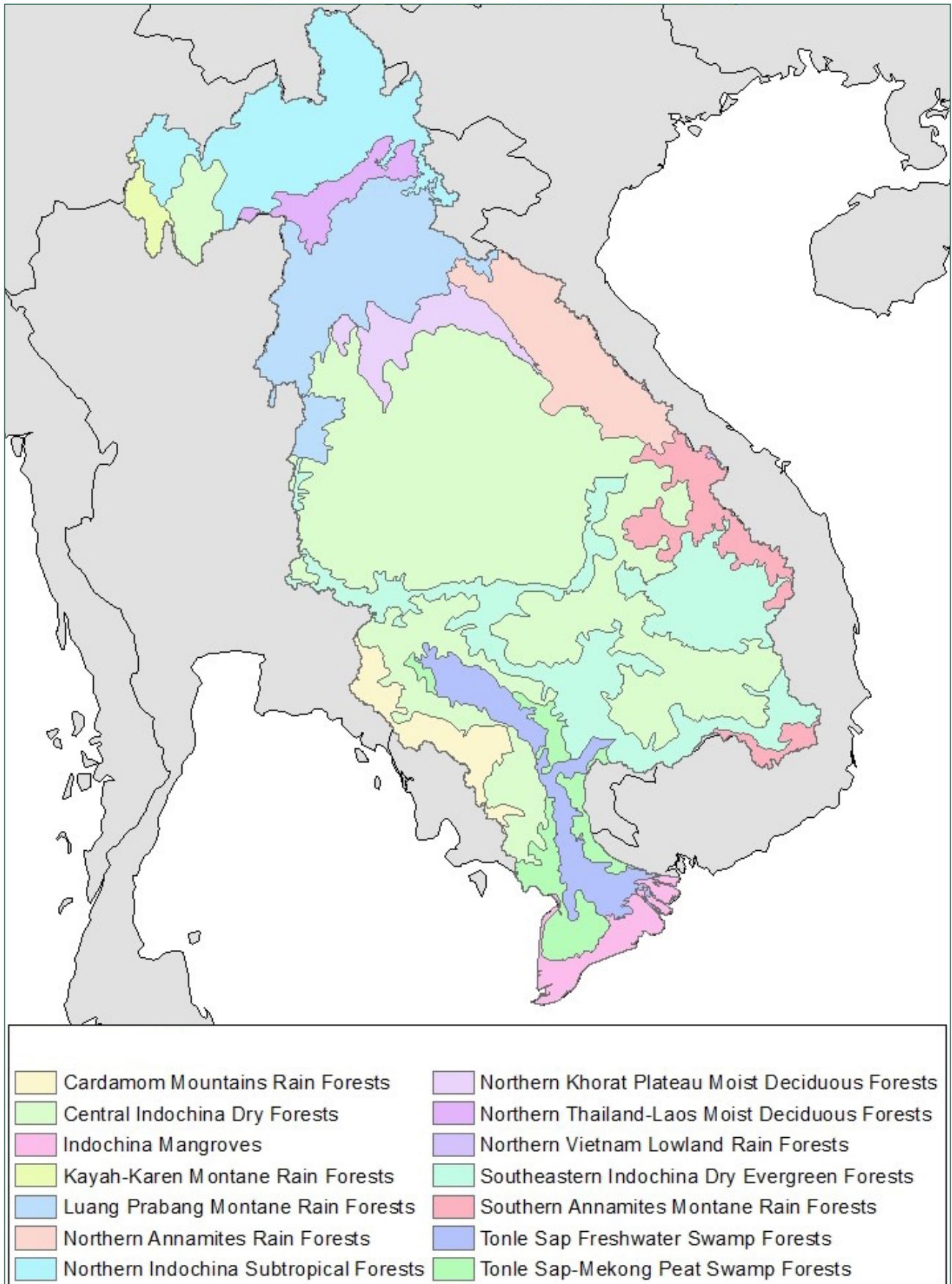
The concept of ecoregions goes back at least as far as 1976 and was adopted by the United States Forest Service by the mid-1990 for ecosystem management. Ecoregions are associated with broad ecological zones, land cover and forest types — primarily described in terms of dominant vegetation type. In 2004, American geographer James Omernik defined ecoregions as “areas

Three major habitat types in the Lower Mekong Basin



SOURCE: OLSON (2001)

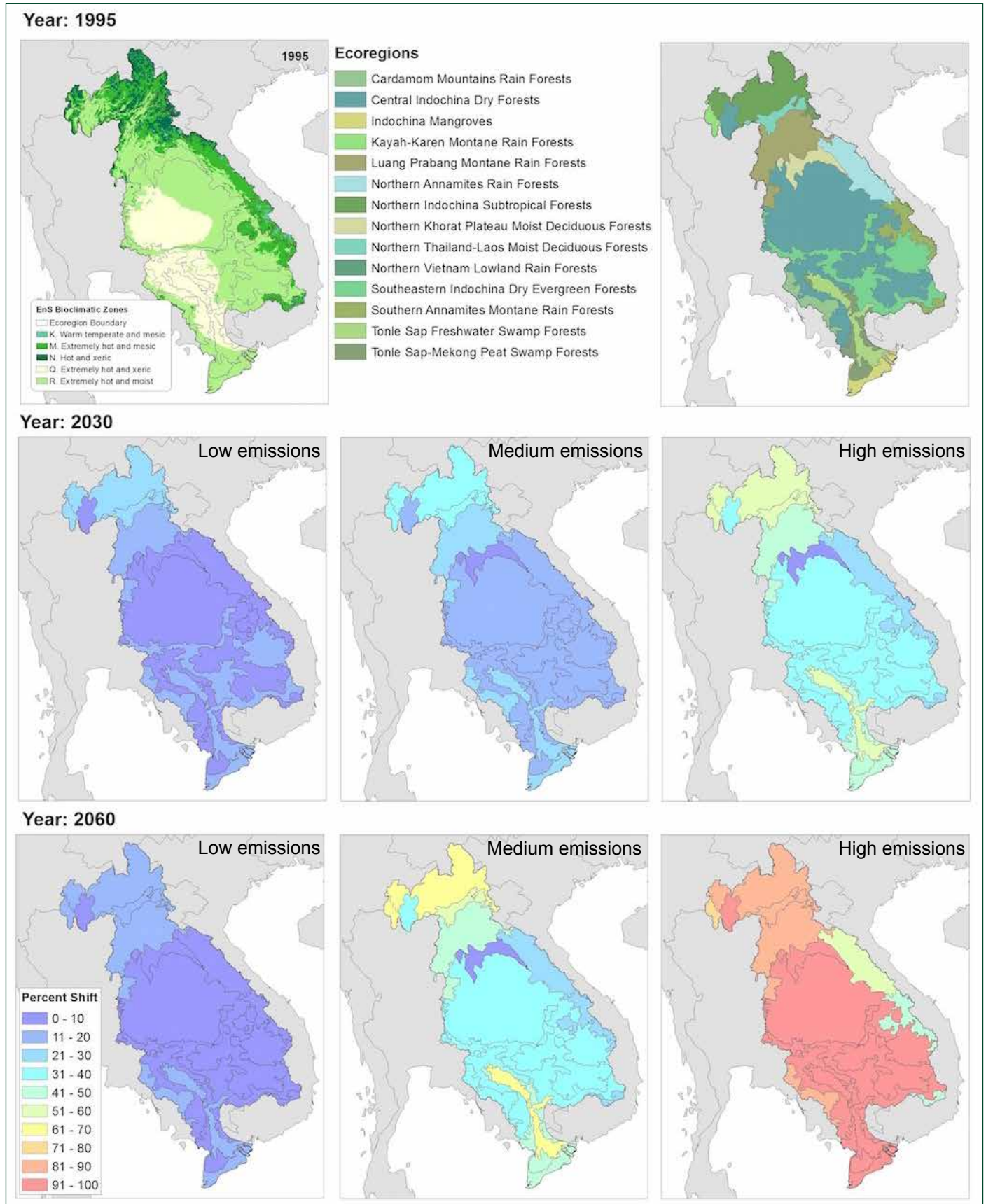
Fourteen ecoregions in the Lower Mekong Basin



SOURCE: OLSON (2001)

Wetter scenario

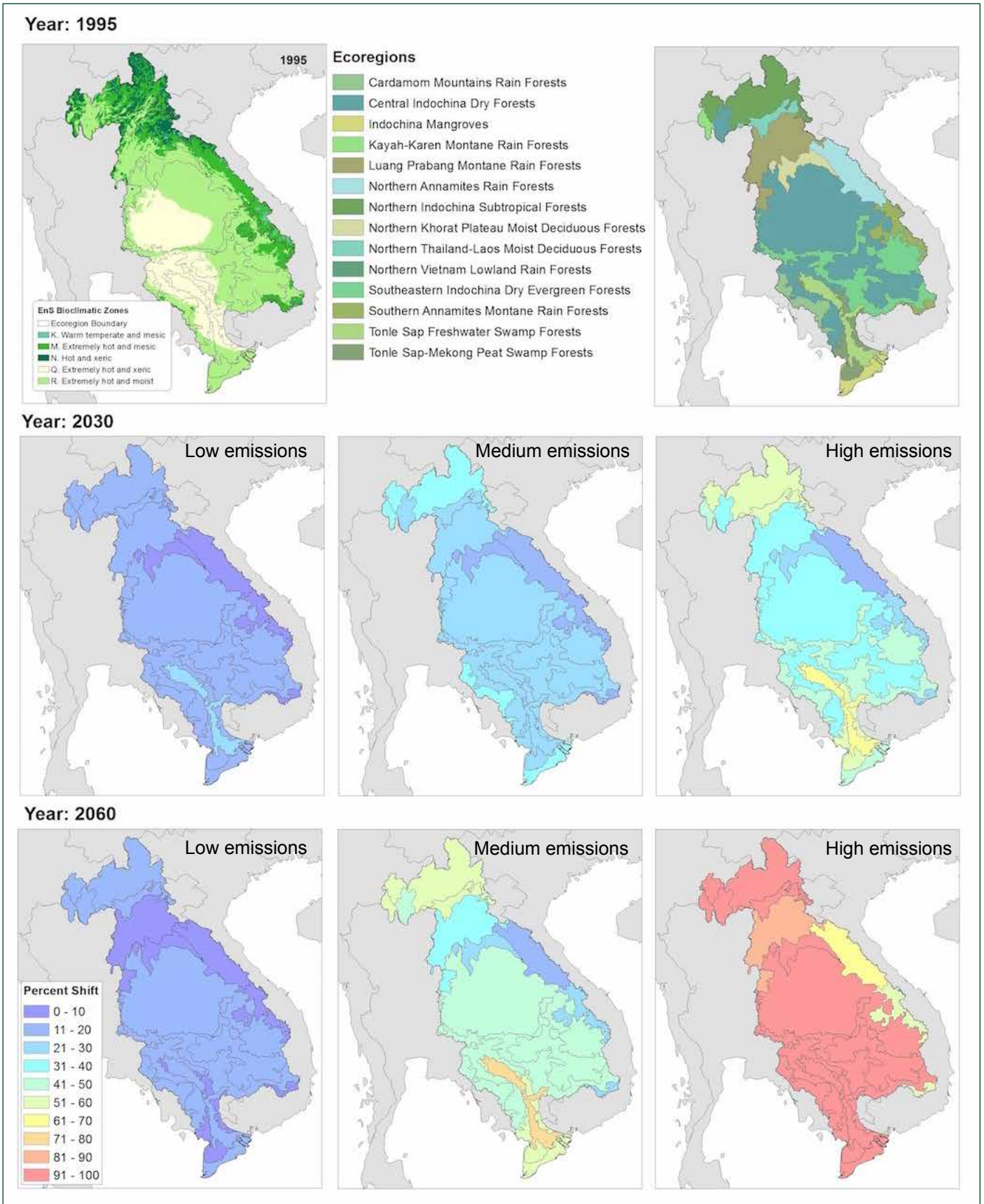
Average percent of area of each ecoregion that shifts to a different bioclimatic zone



SOURCE: MRC (2017)

Drier scenario

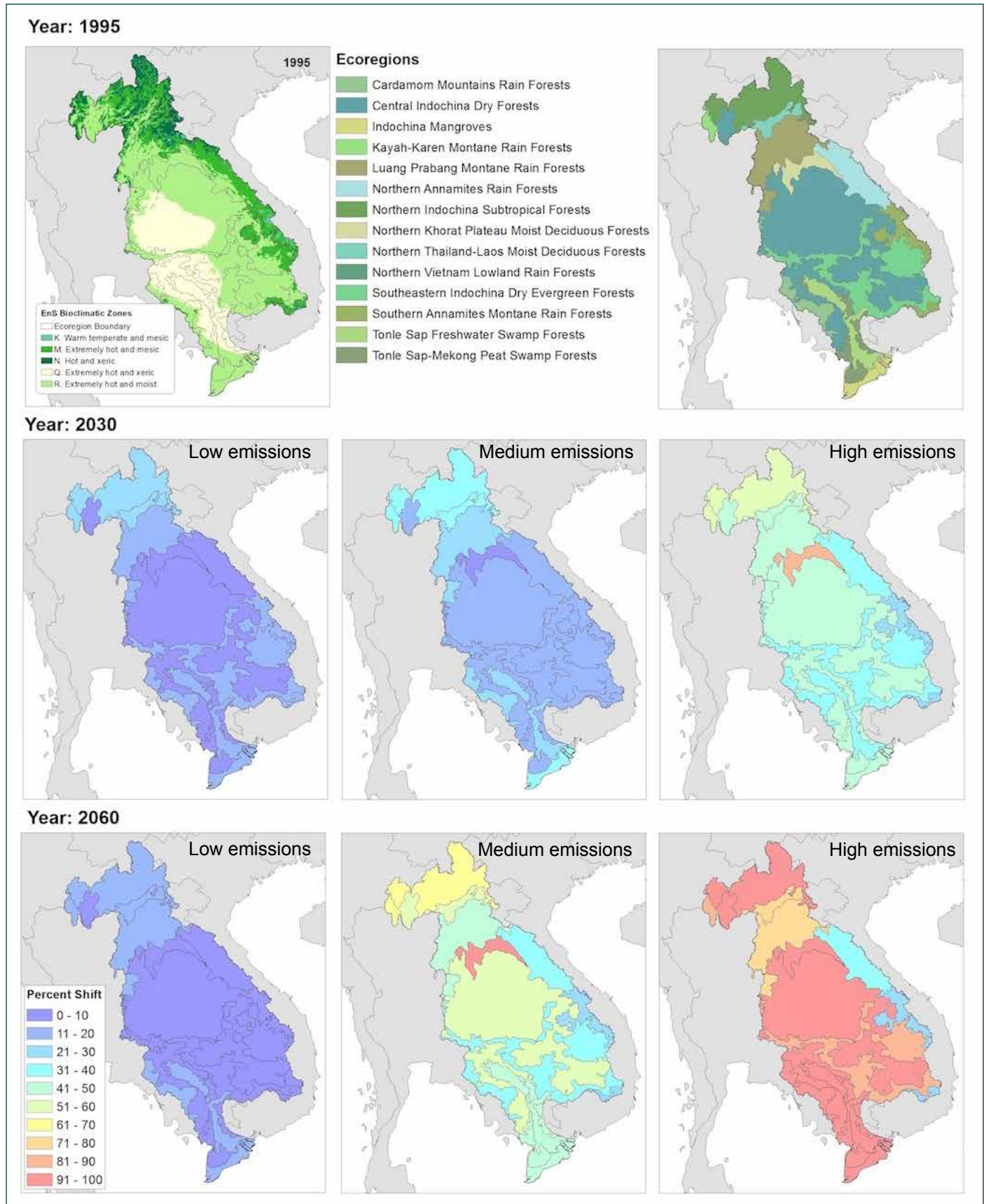
Average percent of area of each ecoregion that shifts to a different bioclimatic zone



SOURCE: MRC (2017)

Increased seasonal variability scenario

Average percent of area of each ecoregion that shifts to a different bioclimatic zone



SOURCE: MRC (2017)

within which there is spatial coincidence in characteristics of geographical phenomena associated with differences in the quality, health, and integrity of ecosystems.”

A paper published in the journal *BioScience* three years earlier defined an ecoregion as a "large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions". According to the authors, the world has 26 major types of terrestrial, freshwater and marine habitat. Fourteen are terrestrial of which three are found in the Lower Mekong Basin — tropical and subtropical dry broadleaf forests (covering 54 percent of the basin), tropical and subtropical moist broadleaf forests (44 percent) and mangroves (2 percent) (see page 22). Within these three major habitat types are 14 ecoregions, the most extensive being the Central Indochina dry forests (41 percent of the basin). Other major regions are the Southeastern Indochina Dry Evergreen Forests (13 percent), the Northern Indochina Subtropical Forests (10 percent) and the Luang Prabang Montane Rain Forests (9 percent). (see page 23)

How bioclimatic conditions could shift

The proportion of each ecoregion that shifts to a different bioclimatic zone indicates exposure to the impacts of climate change. Shifting to a different zone represents the onset of increasingly new or unusual conditions in an area with consequences for biota, ecosystems and managed agricultural systems.

Under a wetter scenario for climate change, the analysis found that the Kayah-Karen Montane Rain Forests (northern Thailand), the Northern Indochina Subtropical Forests spanning (northern Thailand and Lao PDR as well as northeast Viet Nam) and the Northern Thai-Lao Moist Deciduous Forests experience the most spatial shifting by 2030. All three shift more than 34 percent under the medium-emissions scenario and more than 50 percent under the high-emissions scenario. By 2060, projections show more than 50 percent of these three ecoregions shifting to different bioclimatic zones with medium emissions, rising to more than 80 percent with high emissions. Under the high-emissions scenario, six regions are projected to have novel conditions across their entire area by 2060 (see page 24).

Under a drier scenario, the Cardamon Mountains in western Cambodia, the Kayah-Karen Montane Rain Forests, the Northern Indochina Subtropical Forests and the Indochina Mangroves in the Mekong Delta in Viet Nam were found to experience the most spatial shifting by 2030. These shifts exceed 33 percent for all four ecoregions under the medium-emissions scenario. By 2060, six ecoregions show shifts of more than 50 percent to different bioclimatic zones under the medium-emissions scenario. Ten indicate shifts exceeding 90 percent under the high-emissions scenario (see page 25).

Under the third scenario of increased seasonal variability, the analysis found that the Kayah-Karen Montane Rain Forests, the Northern Indochina Subtropical Forests and the Indochina Mangroves experience the biggest shifts by 2030 — more than 33 percent under the medium-emissions scenario. By 2060, five ecoregions show shifts of more than 50 percent to different zones with medium emissions. Under the high-emissions scenario, seven show shifts of more than 90 percent (see page 26).

These spatial shifts “will impact upon and have increasingly substantial and direct impacts on ecosystems, biodiversity, agricultural crops, pastoral systems, water resources, as well as human health and livelihoods, throughout this region as this century progresses,” the analysis found. “Likewise, effectiveness of conservation efforts will be affected, as ecological conditions across the region may change beyond limits conducive for the species currently found within narrow niches or designated protected areas, or allow for newly invasive species.”

Further reading

MRC (2017) Projected Climate Change and impact on bioclimatic condition and terrestrial ecosystems in the Lower Mekong Basin. Mekong River Commission, Vientiane.

Olson, D., Dinerstein, E., Wikramanayake, E. (2001) Terrestrial ecoregions of the world: a newmap of life on earth. *BioScience*.

Omernik, J.M. (2004) Perspectives on the Nature and Definition of Ecological Regions. *Environmental Management*. Volume 34. Supplement 1.

Significant impacts of climate change on fisheries subject to uncertainty

The annual State of Agricultural Commodity Markets is one of the flagship publications of the Food and Agricultural Organisation of the United Nations (FAO). Released on September 17, the latest edition focuses on what the FAO describes as the “complex and underexplored” relationships between agricultural trade, climate change and food security. Below is a summary of the section that deals with fish trade, with a focus on inland fisheries and aquaculture.

Fish and fish products are among the most highly traded foods. In 2016, about 35 percent of global fish production was traded, and in general it is estimated that as much as 78 percent is exposed to foreign competition. International fish trade, measured in total real export value, has grown substantially over the past four decades. Between 1976 and 2016, total traded value increased fourfold from \$33.1 billion to \$142.5 billion. The international trade in fish made up 52 percent of total animal protein trade value in 2016.

‘Adaptive capacity will vary across species’

The impacts of climate change on both fisheries and aquaculture are expected to be significant, but are subject to uncertainty. Fish will be exposed to a complex mix of changing abiotic conditions, such as changes in temperature, salinity, oxygen and water pH. There will also be changes in biotic conditions, related to shifting distribution and migration patterns, species compositions, and abundance of predators and prey, among other things. These changes may affect the physiology, phenology, and behaviour of fish at any life-history stage, and can increase or reduce local abundance. However, adaptive capacity will vary across species.

Competition for scarce water resources often undervalues the significant contributions of inland fisheries to food security. Inland fisheries in

Iraq, Morocco, Pakistan and Spain already face high stress levels that are expected to become even higher in future. In other countries – such as Cambodia, Colombia, Myanmar, the Central African Republic and the Congo – inland fisheries are, at present, characterized by low stress and it is expected that they will remain so in the future. The implications of climate change for individuals, communities and countries dependent on inland fisheries can be expected to be significant.

Aquaculture has been the world’s fastest growing food production system since the 1970s. Growth in aquaculture production has been supported by new technologies that have facilitated the domestication of new species and the development of more productive strains. Higher water temperatures due to climate change may increase the rate of growth of cultured stock, which may enhance aquaculture production.

‘Adaptive capacity of aquaculture is perceived to be higher than in fisheries, as the control over the production processes facilitates the shift in production to more suitable locations and species’

However, when temperatures rise above the optimal range, they could lead to reduced feed intake and feed utilization efficiency. For pond-raised species, the salinity of soil may create an additional challenge. In general, however, the adaptive capacity of aquaculture is perceived to be higher than in fisheries, as the control over the production processes facilitates the shift in production to more suitable locations and species.

Our knowledge of the impacts of climate change on livelihoods revolving around fisheries and aquaculture is more limited. However, a study on the vulnerability of 132 national economies to the climate change impact on fisheries, suggests that the most vulnerable communities tend to be in tropical Africa, north-western South America



Workers at the National Breeding Centre for Southern Freshwater Aquaculture in Viet Nam harvesting giant pangasius (*Pangasius sanitwongsei*) fingerlings in November for sale to fish farmers in the Mekong Delta. Based in Cai Be in Tien Giang Province, the breeding centre is operated by the Research Institute for Aquaculture No 2 (RIA 2) in Ho Chi Minh City. The giant pangasius can grow to three metres and is native to the Mekong Basin as well as the Chao Phraya Basin in Thailand. According to the International Union for the Conservation of Nature (IUCN), the fish is a "critically endangered" species which faces "extremely high risk of extinction in the wild in the immediate future."

PHOTO: CHHUT CHHEANA

and in Asia, where fish consumption makes up a very high share of the protein and nutrients in diet. These countries have also struggled with the additional challenges posed by overfishing and declining fisheries landings, underlining the fact that the effects of climate change on societies and food security are not confined to the direct physical impacts.

Fisheries and aquaculture are critically important for millions of people in coastal, riverine, insular and inland regions whose livelihoods depend

on the sector. These population groups are the most vulnerable to the impacts of climate change, and particular attention needs to be given to them while designing adaptation measures if the fisheries sector is to continue to contribute to meeting global goals of poverty reduction and zero hunger.

Further reading

FAO. 2018. The State of Agricultural Commodity Markets 2018. Agricultural trade, climate change and food security. Rome.

MRC Council reaches conclusions on key managerial and policy matters

Cambodian named to succeed outgoing chief executive officer from Viet Nam

Ministerial delegates from the Mekong River Commission (MRC) Council have reaffirmed the organization's reform commitment and regional relevance as it agreed on key issues, including the endorsement of the selected candidate for the MRC Secretariat's second riparian Chief Executive Officer and the annual work plan for 2019, including priority works.

The MRC Council is the highest, ministerial level of the organization, composed of water resources and environment ministers from the member countries of Cambodia, Lao PDR, Thailand and Viet Nam.

During the annual gathering in Ha Long City on November 28 and 29, the Council endorsed the recruitment report by the MRC's management body the Joint Committee on the second riparian CEO of the MRC Secretariat and named Mr. An Pich Hatda of Cambodia as the next CEO. Currently serving as MRC Secretariat's Director of Planning Division, the incoming CEO is expected to take up his office in late January 2019 for a three-year tenure.

This is the second time the MRC has appointed a CEO from one of the four member countries, following the first appointment of the current CEO, Mr. Pham Tuan Phan, of Viet Nam. The move is in line with the MRC's riparianization policy and



Delegates address the MRC Council meeting in Ha Long City

PHOTO: MRC

goal of becoming financial self-sufficient by 2030.

The Council also approved the annual work plan for 2019, with a budget of about \$15.8 million. The annual work plan is the detailed operational plan, activities and tasks along with associated budgets to implement the organization's strategic plan at the regional level.



The Council comprises water and environment ministers who meet once a year

PHOTO: MRC

The approved plan prioritizes on the commencement of updating the basin development strategy and its implication for the new strategic plan for 2021-2025. It also focuses on finalizing and publishing the Mekong state of the basin report 2018, which provides information on the status and trends of water and related resources in the Mekong basin.

Gender mainstreaming, stakeholder engagement and communication, and uptake of already delivered and produced products, such as the Mekong climate change adaptation strategy and action plan, the basin-wide fisheries strategy, the navigation master plan, and the Council Study, are also among the top priorities for next year. Strengthening the efficiency and effectiveness of the Commission's Regional Flood Management and Mitigation Center to deliver effective, fast and reliable information on both flood and drought is also on the agenda.

The Council also agreed to continue discussion and consensus-building around other key areas, such as the update of the sustainable hydropower development strategy, the preliminary design guidance for mainstream dams, and transboundary environment impact assessment guidelines.

In its preparatory meeting for the Council meeting the day before, the Joint Committee, having heard and discussed the Xayaburi design changes

review report, agreed that it would be used as a valuable technical reference document. The MRC Secretariat and member countries are encouraged to take stock of and learn from it for the benefit of basin development and sustainability.

The Xayaburi design changes review report is the result of the MRC Secretariat's study to determine whether the recommendations from the prior consultation's Xayaburi Technical Review Report by the MRC Secretariat have been taken up in the re-design of the Xayaburi project. It notes the substantial efforts and investment made by Lao PDR in addressing the comments of the MRC and stakeholders.

In the meeting, Development Partners of the MRC also welcomed the efforts and strong level of commitment of the MRC member countries to strengthen cooperation over the sustainable development and management of the Mekong river basin. They stressed the crucial role of the MRC in promoting the reasonable and equitable utilization of water resources and supporting member countries in this course.

The MRC has continued to receive new funding commitments from Development Partners for the implementation of the strategic plan 2016-2020, with funding agreements to be signed between the MRC and Germany and the European Union at the sidelines of the Council meeting.

New human capital index reflects investments in health and education

A new index unveiled by the World Bank at its annual meeting in Bali on October 11 shows that Viet Nam outranks its Mekong neighbours in terms of human capital. On a global basis, Viet Nam is singled out for achieving a “meteoric rise in learning” in terms of quality-adjusted schooling, which combines information on both the quantity and quality of education. Below is a summary of the chapter on human capital in the bank’s World Development Report 2019: The Changing Nature of Work, released a day after the new index was launched

Human capital consists of the knowledge, skills, and health that people accumulate over their lives, enabling them to realise their potential as productive members of society. It has large payoffs for individuals, societies, and countries. For individuals, an additional year of school generates higher earnings on average. These returns are large in low and middle-income countries, especially for women.

However, what children learn matters more than how long they stay in school. In the United States, replacing a low-quality teacher in an elementary school classroom with an average-quality teacher raises the combined lifetime income of that classroom’s students by US\$250,000. Returns to education are especially high when technology is changing people with higher human capital adapt faster to technological change.

Developing skills such as an aptitude for teamwork, empathy, conflict resolution, and relationship management enlarges a person’s human capital. Globalised and automated economies put a higher premium on human capabilities that cannot be fully mimicked by machines. Abilities such as grit have economic returns that are often as large as those associated with cognitive skills.

Health is an important component of human capital. People are more productive when they are healthier. From an early age, the dimensions

of human capital complement each other. Proper nutrition in utero and in early childhood improves children’s physical and mental well-being. A multi-

country study in Southeast Asia found that both underweight and obese children had lower IQ scores than healthy-weight children. The benefits of human capital transcend private returns, extending to others and across generations. Deworming one child decreases the chances of other children becoming infected with worms, which sets those children up for better learning and higher wages. Maternal education, through better prenatal care, improves infant health.

Large benefits for economies

These individual returns to human capital add up to large benefits for economies—countries become richer as more human capital accumulates. Human capital complements physical capital in the production process and is an important input to technological innovation and long-run growth. As a result, between 10 and 30 percent of per capita gross domestic product (GDP) differences is attributable to cross-country differences in human capital. This could be even higher when considering quality of education or interactions between workers with different skills.

Credible measurement of education and health outcomes raises the importance of human capital locally, nationally, and globally. Measurement spurs the demand for policy interventions to build human capital in countries where governments are not doing enough. Good measurement is essential to developing research and analysis to inform the design of policies that improve human capital.

With this goal in mind, the World Bank has launched the human capital project—a program of advocacy, measurement, and analytical work

Human Capital Index

Rank	Economy	Value
48	Viet Nam	0.67
65	Thailand	0.60
100	Cambodia	0.49
111	Lao PDR	0.45

Source: World Bank (2018a)

to raise awareness and increase demand for interventions to build human capital. The project has three components: (1) a cross-country metric—the human capital index, (2) a program of measurement and research to inform policy action, and (3) a program of support for country strategies to accelerate investment in human capital.

The new index measures the amount of human capital that children born in 2018 can expect to attain by age 18 in view of the risks of poor education and poor health that prevail in the country in which they were born. The index is designed to highlight how improvements in the current education and health outcomes shape the productivity of the next generation of workers: it assumes that children born in a given year experience current educational opportunities and health risks over the next 18 years. A focus on outcomes—and not inputs such as spending or regulation—directs attention to results, which are what really matter. It also makes the human capital index relevant to the policy makers who design and implement interventions to improve these outcomes in the medium term.

Three components

The human capital index quantifies the milestones in terms of their consequences for the productivity of the next generation of workers. It has three components: (1) whether children survive from birth to school age (age five); (2) expected years of quality-adjusted school, which combines information on the quantity and quality of education; and (3) stunting and adult survival rates.

The index can be connected to scenarios for future per capita income and growth. Imagine a status quo scenario in which the expected years of quality-adjusted school and level of health persist into the future. Over time, new entrants to the workforce with status quo education and health replace

current members of the workforce, until eventually the entire workforce of the future has the expected years of quality-adjusted school and level of health captured in the current human capital index. It is possible to then compare this scenario with one in which the entire future workforce benefits from a complete education and enjoys full health.

In the long run, per capita GDP in this scenario is higher than in the status quo scenario through two channels: direct effects of higher worker productivity and indirect effects that reflect the greater investments in physical capital induced by having more productive workers. For example, a country with an index of $x = 0.5$ would in the long run have per capita incomes twice as high as the status quo if its citizens enjoyed a complete education and full health. What this means in terms of average annual growth rates depends on the time period. If 50 years—or about two generations—are required for these scenarios to materialise, then a doubling of future per capita income relative to the status quo corresponds to roughly 1.4 percentage points of additional growth per year.

Viet Nam's remarkable performance

Viet Nam's experience illustrates the potential benefits of mapping path-ways of change. The country's schoolchildren scored in the top quarter of the mostly middle and high-income countries that participated in the 2012 and 2015 Programme for International Student Assessment (PISA). This performance is remarkable in view of Viet Nam's level of per capita income. Understanding this success could provide important lessons for how to ensure that schooling achieves learning.

Further reading

World Bank (2018a) The Human Capital Project. World Bank, Washington

World Bank (2018b) World Development Report 2019: The Changing Nature of Work. World Bank, Washington

Human Capital Index and components, 2018

Economy	Probability of survival to age 5	Expected years of school	Harmonized learning outcome	Learning adjusted years of school	Adult survival rate	Fraction of children under 5 not stunted
Cambodia	0.97	9.5	452	6.9	0.83	0.68
Lao PDR	0.94	10.8	368	6.4	0.81	0.67
Thailand	0.99	12.4	436	8.6	0.85	0.89
Viet Nam	0.98	12.3	519	10.2	0.88	0.75

Source: World Bank (2018a)

Fisheries in the People's Republic of Kampuchea (1979 - 1989)

This month marks the 40th anniversary of the foundation of the United Front for the National Salvation of Kampuchea on December 2, 1978. Chaired by former military commander Heng Samrin, now president of the Cambodian National Assembly, the front oversaw the toppling of Pol Pot's forces five weeks later and the establishment of the People's Republic of Kampuchea which ruled the country until 1989. How did fisheries management evolve during this period? We asked Dr Nao Thuok, the former Director-General of the Cambodian Fisheries Administration who now serves as Secretary of State (vice minister) at the Ministry of Agriculture, Forestry and Fisheries in Phnom Penh.

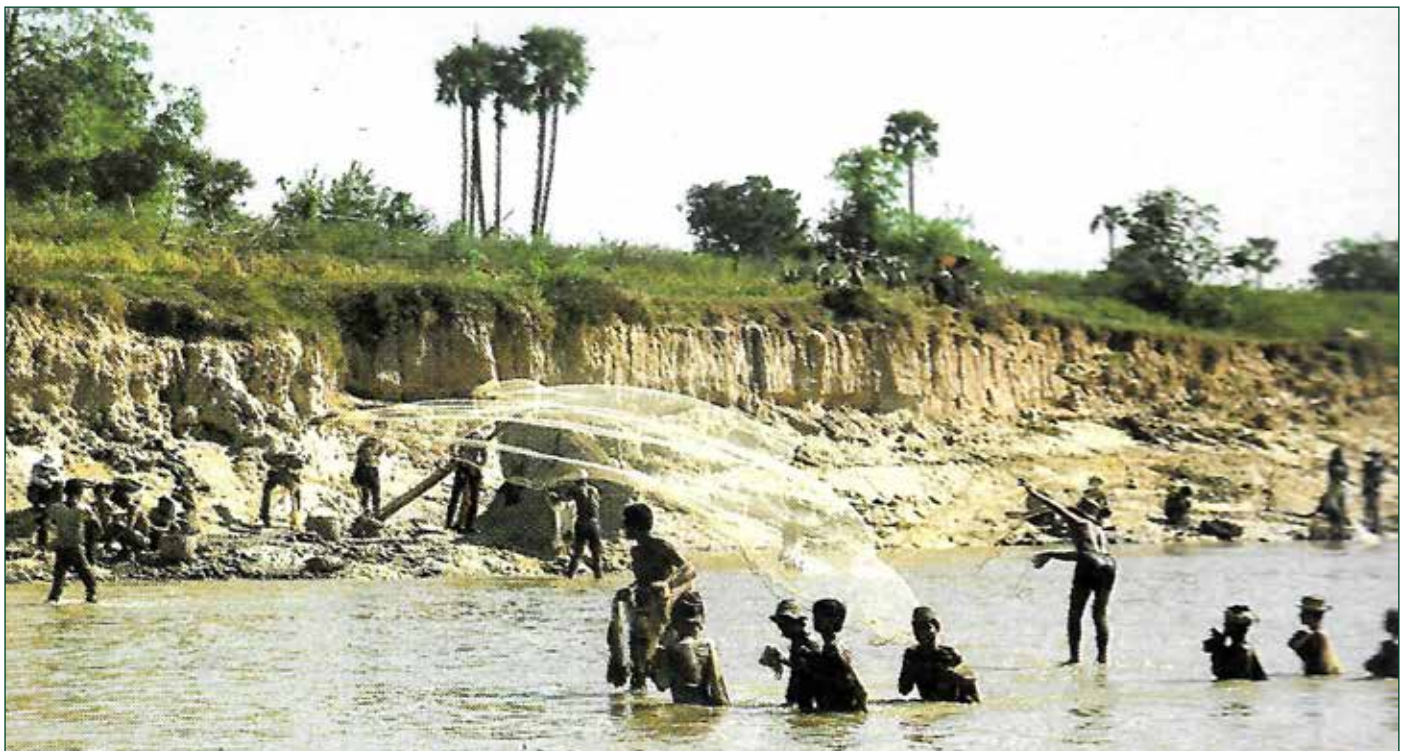
Born in Takeo Province in southwestern Cambodia, Dr Nao Thuok was a young Fisheries Department officer in Phnom Penh when Pol Pot's

forces took the city in April 1975. He was forcibly evacuated from the capital to the Northwestern Zone in what is now Banteay Meanchey Province. Three and a half years later, he was working as a labourer pulling oxcarts when he and his friends first heard about the uprising in the east. They found out by radio (the United Front established the Voice of the Kampuchean People on December 3, 1978, a day after the front was launched in Kratie Province). "We whispered to each other. We had mixed feelings. We had great hope that we would be rescued. But at the same time, we were afraid they'd kill us," he said, referring to Pol Pot's forces



HE Dr Nao Thuok

PHOTO: CHHUT CHHEANA



After liberation from the Pol Pot regime in 1979, Cambodians were free to go fishing everywhere

PHOTO: KAMPUCHEA TODAY PUBLISHED BY ORBIS PRESS AGENCY (PRAGUE) AND SAPORDARMEAN KAMPUCHEA (PHNOM PENH) IN 1988



A giant barb (*Catlocarpio siamensis*) caught during the 1980s. Under a royal decree issued in 2005, this species is considered the “national fish” of Cambodia, requiring protection and conservation. Since 2011, the giant barb has been classified as “critically endangered” by the International Union for the Conservation of Nature (IUCN). Such species are considered to be at “extremely high risk of extinction in the wild in the immediate future.”

PHOTO: KAMPUCHEA TODAY PUBLISHED BY ORBIS PRESS AGENCY (PRAGUE) AND SAPORDARMEAN KAMPUCHEA (PHNOM PENH) IN 1988

who would later be blamed for the deaths of some two million people between 1975 and 1979.

With his wife, two infant children and several in-laws, Dr Nao Thouk and his family made their way to Kralanh District in Siem Reap Province (Siem Reap was liberated by United Front and Vietnamese forces on January 10, 1979, three days after Phnom Penh). “My brother in law had a cart. The others were walking,” he said. In Kralanh, the family were able to locate tools to

make watering cans which could be exchanged for rice.

‘There were a lot of fish everywhere’

Dr Nao Thouk eventually resumed working for the Fisheries Department at its provincial office in Siem Reap. Unlike during the Khmer Rouge regime, when people could get killed for catching fish, Cambodians were now free to resume fishing. “In 1979, there was no law but a lot of fish. You could go fishing everywhere,” he said. “There was



A floating bagnet fishing operation (*dai*). The flag of the People's Republic of Kampuchea from 1979 to 1989 was the original flag of the Khmer People's Revolutionary Party. The party was founded in 1951 when the colonial-era Indochinese Communist Party dissolved into separate Cambodian, Lao and Vietnamese parties. The flag showing the five-tower temple of Angkor Wat was revived on December 2, 1978, when the United Front for the National Salvation of Kampuchea was formed. It replaced a three-tower flag used by the Khmer Rouge since 1975..

PHOTO: KAMPUCHEA TODAY PUBLISHED BY ORBIS PRESS AGENCY (PRAGUE) AND SAPORDARMEAN KAMPUCHEA (PHNOM PENH) IN 1988

no large-scale fishing. Maybe there were some small nets — there were a lot of fish everywhere.” Around 1981, he said the new administration led by Heng Samrin started providing funds, loans and fishing gear to help revitalise the fishing industry. In 1983, Dr Nao Thuok travelled abroad for the

first time, joining several hundred Cambodians for training in political theory in Ho Chi Minh City.

The Fifth Congress of the Khmer People's Revolutionary Party in 1985 paved the way for renewed auctions for fishing lots (introduced

by the French in 1908 and abolished in 2012 — see *Catch and Culture*, Vol 18. No 1). During the congress, the party recognised the private sector as the fourth pillar of the economy (after state-owned enterprises, collectives and small family businesses).

“Before that, we had no auctions of fishing lots. But we had fisheries cooperatives to exploit fish from the Tonle Sap,” Dr Nao Thuok said. After the party recognised the private sector, he said the Fisheries Department passed Fiat Law No. 33 in 1987 which provided for auctions. By 1989, the number of fishing lots being auctioned had reached 239. These were located around the Tonle Sap and along the Mekong and Bassac Rivers. Auctions included the *dai* stationary bagnet fishery on the Tonle Sap River, which had partly resumed operating after 1979 at the request of the Fisheries Department.

The fisheries officer ventured further abroad in 1988 to study crocodile farming in Cuba, home to the critically endangered Cuban crocodile (*Crocodylus rhombifer*) which has been bred at the Cienaga de Zapata Crocodile Farm in Matanzas Province south of Havana since 1959. It was here that he first met Dr Roberto Ramos Targarona, the Cuban crocodile specialist who he would later meet on subsequent trips abroad including to Bangkok, Darwin and Singapore as well as Lake Charles in Louisiana in the United States.

Transporting fish by elephant

Back in Siem Reap, Dr Nao Thuok said that breeding the native Siamese crocodile (*Crocodylus siamensis*) proved challenging. The crocodiles, now also critically endangered in the wild, were fed on fish transported by elephant from the Tonle Sap Lake (the crocodiles have more recently been fed on water snakes — see page 14). “But it was difficult to sell baby crocodiles and we couldn’t export,” he said, adding that falling prices for farmed crocodiles made the business



A ceremony marking the 40th anniversary of the founding of the United Front on December 2 this year featured a re-enactment of the overthrow of Pol Pot forces on January 7, 1979. The ceremony, presided over by National Assembly President Samdech Heng Samrin, was attended by an estimated 30,000 people and took place in Snuol in the eastern province of Kratie where the front was established in 1978.

PHOTO: PHEOURN PHORN / CAMBODIAN NATIONAL ASSEMBLY

uneconomic. But other factors may have also been at play. “Farmers were told that during the Khmer Rouge regime, people were fed to crocodiles.”

Elephant transport underscored severe fuel shortages during the 1980s and the lack of transportation means. Under the Khmer Rouge regime before 1979, such shortages were so intense that Irrawaddy dolphins (*Orcaella brevirostris*) were being caught to use as fuel for motorboats. “They were killing as many as five dolphins a day,” Dr Nao Thuok recalled, adding that each animal could produce 25 litres of fuel oil.

The People’s Republic of Kampuchea was succeeded by the State of Cambodia in 1989 and ultimately the Kingdom of Cambodia under a new constitution in 1993.

Further reading

Heng S (2018) *The People’s Struggle: Cambodia Reborn*. Editions Didier Millet, Singapore.

Ramos Targarona, R., Soberón, R.R., Tabet, M.A. and Thorbjarnarson, J.B. (2010) Cuban Crocodile *Crocodylus rhombifer*. Pp. 114-118 in *Crocodiles. Status Survey and Conservation Action Plan*. Third Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group, Darwin.

Freshwater species abundance seen falling 83 pct between 1970 and 2014

On October 29, the World Wildlife Fund (WWF) released its latest Living Planet Index produced in collaboration with the Zoological Society of London. The index tracks global biodiversity by measuring the abundance of 16,704 populations of 4,005 vertebrate species. The latest shows that global populations of these mammals, birds, fishes, reptiles and amphibians declined by 60 percent between 1970 and 2014, the latest years for which data is available. During the same period, freshwater index for 3,358 populations of 880 freshwater vertebrates plunged 83 percent. WWF said the steepest declines in freshwater populations were in Central and South America (down 94 percent), the Indo-Pacific region (down 82 percent) and Africa (down 75 percent) — especially reptiles, amphibians and fishes. Details of the latest index can be found in the 144-page report published by WWF headquarters in Switzerland. The following is a summary of the report's section on the importance of healthy freshwater systems.

Freshwater ecosystems contain disproportionately more species per unit area than marine and terrestrial ecosystems. Although they cover less than 1 percent of the Earth's surface, freshwater habitats are home to more than 10 percent of known animals and about one-third of all known vertebrate species. These distinct ecosystems are under increasing levels of threat and, the trend for freshwater species is alarming. For example, in the 20th century, freshwater fishes have had the highest extinction rate worldwide among vertebrates.

Freshwater ecosystem health is defined by its water quality and quantity, connectivity to other parts of the system and landscape, habitat condition, and diversity of plant and animal species. The pressures created by human settlements and infrastructure, water use, pollution, overexploitation, invasive species and climate change are impinging on all aspects of the health of rivers, lakes and wetlands.

Globally, wetland extent is estimated to have declined by more than 50 percent since 1900. Rivers are increasingly disconnected due to dams and other infrastructure, with reservoirs altering natural flow regimes and trapping more than 25 percent of the total sediment load globally that formerly reached the ocean. Freshwater ecosystems are also impacted by increasing withdrawal and consumption of surface water for a variety of uses but dominated by agriculture, which is responsible for about 70 percent of total consumption.

Water quality is also of concern, with eutrophication and toxic pollution being major sources of water quality degradation. Finally, climate change is exacerbating existing stressors and causing changes in the timing, availability and temperature of waters, affecting the condition of freshwater habitats and the life history of freshwater species.

Connected, flowing rivers

Almost every ancient civilisation can trace its origins to a major river. That's because river systems, including their floodplains and deltas, are among the most biologically diverse and productive ecosystems on the planet. Freshwater and inland fisheries provide the primary source of protein for hundreds of millions of people worldwide. By depositing nutrient-rich silt on floodplains and deltas, rivers have created some of the most fertile agricultural land.

For these and other economic and ecosystem benefits to be realised, rivers must retain key characteristics and processes. When natural connectivity and flow are retained the river is called "free-flowing". However, infrastructure development — especially dams — has caused a dramatic decline in the number of these; currently there are more than 50,000 large dams worldwide. Undammed rivers are still at risk with more than 3,600 hydropower dams planned globally. Options for protecting rivers can entail both preventing the construction of poorly planned

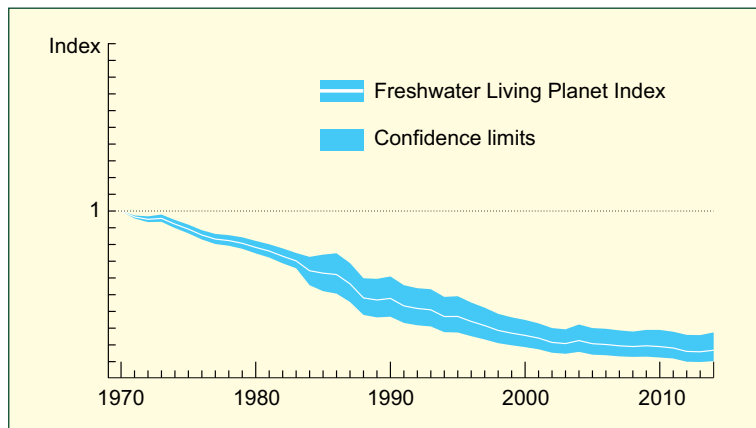
dams and ensuring that any dams that are constructed are located and designed to mitigate environmental damage as much as possible. There are plenty of examples where public engagement has influenced dam siting and prices for renewable sources, such as wind and solar, are dropping precipitously alongside other advances such as grid integration and improved storage technologies. Collectively, this “renewable revolution” can catalyse other pathways for energy development, suggesting that countries can meet energy objectives with less hydropower, and therefore fewer dams, than previously planned.

River protection can also occur via various legal and policy mechanisms. Legal protections for rivers began in the United States which became the first country to pass national-level legislation to protect wild rivers with the National Wild and Scenic Rivers Act in 1968. Recently Mexico created a new model for effectively protecting rivers. The National Water Reserves Program ‘reserves’ a certain percentage of the river’s flow for nature, thus ensuring it will continue to support people and economic activities while maintaining flow and connectivity. Norway’s legal framework offers an excellent example of how planning and policy can direct hydropower toward low-conflict rivers and away from high-conflict rivers. This type of basin-level or system-scale approach can help to avoid costly restoration efforts into the future.

A critical aspect of protecting rivers is maintaining the flow regime necessary to support key river functions and ecosystem services. This flow regime is termed its environmental flow and is defined as “the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems”. The science of environmental flow assessment has advanced rapidly over the last two decades and it is possible now to provide recommendations for environmental flows even in data-scarce regions. Moreover, an increasing number of nations have mandated certain levels of environmental flows as a central tenet of water policy. The implementation of environmental flows often requires challenging shifts in infrastructure planning and water allocation. Still, there are

Freshwater Living Planet Index: 1970 to 2014

The average abundance of 3,358 freshwater populations representing 880 species monitored across the globe declined by 83%. The white line shows the index values and the shaded areas represent the statistical certainty surrounding the trend (range -73% to -90%).



Source: WWF (2018)

an increasing number of known successes in China, Pakistan, South Africa, Australia and the US. These successes seem to have a number of enabling conditions in common, including the existence of progressive legislation and regulation, collaboration and leadership, resources and capacity, and adaptive management. The Brisbane Declaration and Global Action Agenda on Environmental Flows, published in 2018, is a clarion call to governments and stakeholders to build on previous successes through widespread implementation of environmental flows through legislation and regulation, water management programmes and research, linked by partnership arrangements involving diverse stakeholders.

Where river connectivity and flows have already been compromised, actions such as the periodic release of water, floodplain reconnection, or the removal of ageing dams can help to restore ecosystem functions. More than 1,500 dams have now been removed from across Europe and the United States. Analyses of river connectivity metrics combined with other ecological, social and economic variables can reveal where the greatest gains in connected rivers and the values that they provide can be achieved for the lowest cost.

Further reading

WWF (2018) Living Planet Report 2018. Aiming Higher. Grooten, M. and Almond, R.E.A.(Eds). WWF, Gland, Switzerland.

Bleak outlook for cassava in Mekong countries as Chinese demand slumps

FAO warns that impact on small-scale Cambodian, Lao and Vietnamese farmers is a 'major concern' and that a quick shift to other crops could be the only alternative to maintain their livelihoods

World exports of cassava are set to fall 36 percent from a year earlier to a seven-year low in 2018 as China lowers its excessive stockpiles of maize, according to the Food and Agriculture Organisation of the United Nations (FAO). "Not since the decimation of Thailand's cassava crop by the pink hibiscus mealy bug in 2010 and 2011 has total cassava trade fallen so low. On this occasion, however, policy is culpable," the UN agency said in its *Food Outlook* released on November 6. Apart from Thailand, the biannual publication noted that Cambodia, Lao PDR and Viet Nam were among the "few countries" supplying cassava to China. Based on production forecasts for this year, Cambodia, Thailand and Viet Nam are already among the world's top ten producers of the tuberous root (see below).

The FAO said the uncertainty dominating the market in Asia reflected exporters being "strongly susceptible" to developments in China. "Almost all cassava sectors in Southeast Asia have been geared to meet China's traditional high import demand, expanding in tandem with trade growth. However, notwithstanding highly competitive industrial and feed procurement, the immediate future for cassava appears bleak on account of China's ongoing policy to auction government stockpiled maize – cassava's chief rival – to meet internal demand."

"While the auction programme cannot continue indefinitely, ongoing productivity gains could lead to additional stockpiling. Against this, targeted area cuts and a shift to income support in

China's maize sector should assist in lowering the country's large maize surpluses, prompting inflows of maize substitutes including cassava. But the time period for such large-scale adjustment to conclude is indeterminate."

"The potential for cassava to compete in markets beyond China is also uncertain, given that international maize prices are currently hovering at relatively low levels. While cassava root prices in Southeast Asia have firmed in 2018, the outlook for next year and beyond will greatly depend on whether producers would be willing to accept the continued risks of dwindling demand in China. Already some indication is provided by way of a recent official survey of planting intentions in Thailand, which shows optimism in the form of a prospective 5 percent increase in cassava area in 2019."

A rally in international cassava prices that began in the last quarter of 2017 continued into the first six months of this year "but has since lost momentum," the FAO said. In Thailand, which serves as the global benchmark for the international cassava trade, cassava chip prices were around USD 233 per tonne in October, up

World's top cassava producers

	2014	2015	2016	2017	2018*
	(thousand tonnes)				
	World	277,072	276,510	275,655	277,070
1	Nigeria	57,643	57,855	55,069	56,000
2	Thailand	32,358	31,161	30,495	27,240
3	Indonesia	21,801	20,261	19,046	21,000
4	Brazil	23,060	21,080	20,610	20,940
5	Ghana	17,213	17,798	19,138	19,441
6	DR Congo	15,300	15,200	14,950	15,200
7	Cambodia	11,944	13,222	13,387	13,000
8	Mozambique	8,103	9,100	10,920	12,198
9	Viet Nam	10,740	10,925	11,263	10,500
10	Angola	7,727	7,788	7,740	7,724

* Forecast

SOURCE: FAO (2018)



Cassava as depicted by Dutch painter Albert Eckhout in this 17th century painting from Dutch Brazil

ILLUSTRATION: ALBERT ECKHOUT

A study published by America's National Academy of Sciences in 1999 traced the domestication of cassava (*Manihot esculenta*) to populations of a subspecies growing along the southern border of the Amazon Basin in Brazil. The plant is now farmed in more than 100 countries, says the FAO, which has been promoting cassava as a "21st century crop" for the past five years. "The 'food of the poor' has become a multipurpose crop that responds to the priorities of developing countries, to trends in the global economy and to the challenge of climate change," it says in a guide published in 2013. "The roots of cassava are very rich in carbohydrates, which makes them an important source of dietary energy. They can be consumed fresh after cooking, processed into food products, or fed to livestock. Cassava root starch can be used in a wide array of industries, from food manufacturing and pharmaceuticals to production of plywood, paper and bio-ethanol. In some countries, cassava is also grown for its leaves, which contain up to 25 percent protein."

Further reading

Buvelot, Q *et al* (2004) Albert Eckhout, a Dutch artist in Brazil. Royal Cabinet of Paintings Mauritshuis, The Hague, and Waanders Publishers, Zwolle.

FAO (2013) Save and Grow: Cassava. A guide to sustainable production intensification. FAO, Rome.

Olsen, K.M. and B.A. Schaal (1999) Evidence on the origin of cassava: Phylogeography of *Manihot esculenta*. Proc Natl Acad Sci USA. 1999 May 11; 96 (10): 5586–5591

25 percent from a year earlier and also up 49 percent from an eight-year low in May 2017 (see top chart). Flour and starch prices were around USD 507 per tonne, up 44 percent after starting the year at USD 433 and climbing to USD 550 in May (see middle chart). The FAO noted that these benchmark quotations had historically enjoyed a substantial discount to maize and maize starch. “However, owing to domestic developments in Thailand and policy developments in China, the gap between maize and cassava product prices has narrowed significantly over the course of 2018,” the UN agency said.

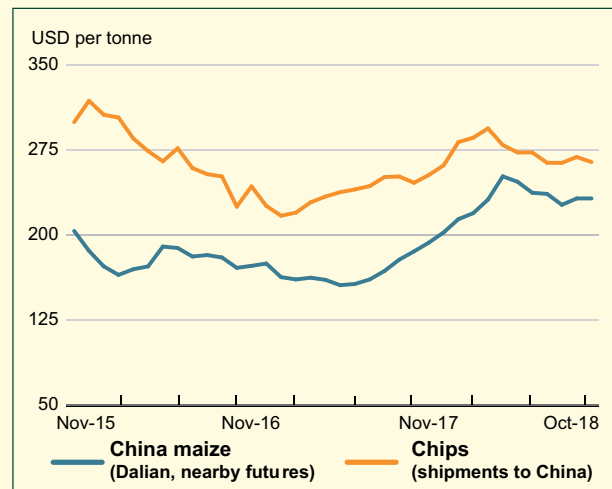
“In Thailand, prices of roots have been on the march since mid-2017, peaking at a seven-year high of USD 99 per tonne in April 2018 (see bottom chart), reflecting lower domestic availabilities from which cassava chips and flour are manufactured. Meanwhile in China, measures to lower its accumulated stockpiles of maize through state auctions have significantly dampened domestic maize prices, hindering demand for cassava.”

‘Industrial demand in the ethanol, starch and animal feed sectors and lucrative markets, especially China, underpinned strong expansion of the crop’

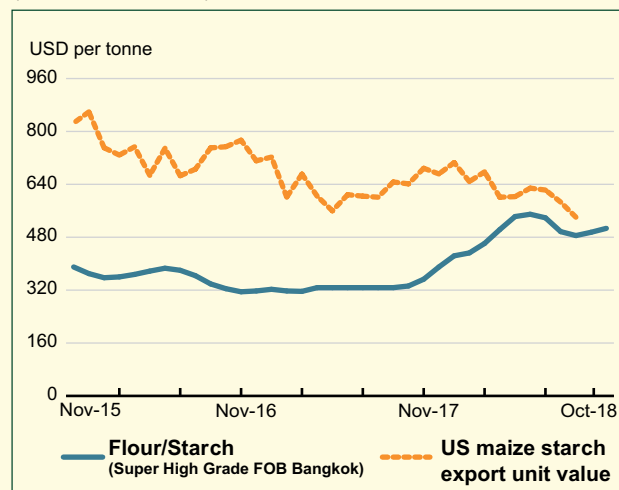
Why has cassava production in Asia expanded so much over the past decade? According to the FAO, industrial demand in the ethanol, starch and animal feed sectors and lucrative markets, especially China, underpinned strong expansion of the crop, especially in Southeast Asia. But output fell throughout Asia in 2017 and is forecast to contract further by a similar margin of around 3 percent in 2018.

“Much of the contraction is due to a reduction in plantings of 10 percent from the previous year in Thailand, Asia’s largest producer, following very low root prices at the beginning of the season and a lack of foreseen demand in China,” the UN agency said. “Consequently, Thailand’s cassava production in 2018 is expected to reach a multi-year low of 27 million tonnes. For similar reasons, a cessation of output growth in Viet Nam and Cambodia, the region’s other prominent cassava

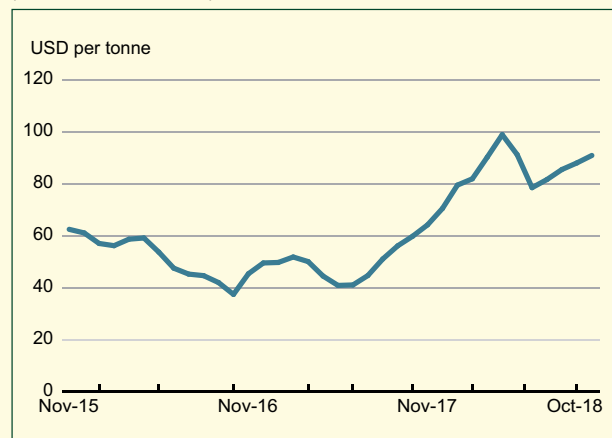
China maize and Thai cassava chips prices
(Nov 2015 - Oct 2018)



International cassava and Thai domestic prices
(Nov 2015 - Oct 2018)



Thai root producer prices
(Oct. 2012 - Oct. 2018)



Source: FAO (2018)

exporters, is also expected in 2018.”

According to the FAO, China typically accounts for more than two-thirds of world imports of cassava, and Thailand for as much as 80 percent of exports. In 2018, exports of chips or pellets alone are forecast to fall 47 percent (see top table). The UN agency said China had sold off 80 million tonnes of maize so far in 2018, triggering a slump in demand for substitutes, notably cassava chips and pellets — effective substitutes for cereals in pig and poultry diets. As a result, China was likely to cut chip imports 51 percent from a year earlier to 4.35 million tonnes in 2018 (see charts below). “Purchases by the other notable buyer of this cassava product — Thailand — also look set to fall, by more than 1 million tonnes from 2017,” the FAO said, noting that these chip imports were from Viet Nam and Cambodia for re-export to China.

Exports of cassava starch — preferred in applications that use native starch and textile industries

World exports of cassava

	2014	2015	2016	2017	2018*
(thousand tonnes)					
Total	19,948	22,061	21,765	21,805	13,874
Flour and Starch	9,068	9,040	9,749	9,576	7,354
Thailand	7,919	7,657	8,446	8,290	6,400
Viet Nam	788	1,011	1,055	1,048	800
Cambodia	29	56	64	146	80
Others	333	316	183	93	74
Chips and Pellets	10,880	13,021	12,016	12,229	6,520
Thailand	6,927	7,458	6,411	6,661	3,900
Viet Nam	2,995	3,607	3,241	3,200	1,200
Cambodia	808	1,805	2,182	2,230	1,300
Others	150	150	181	137	120

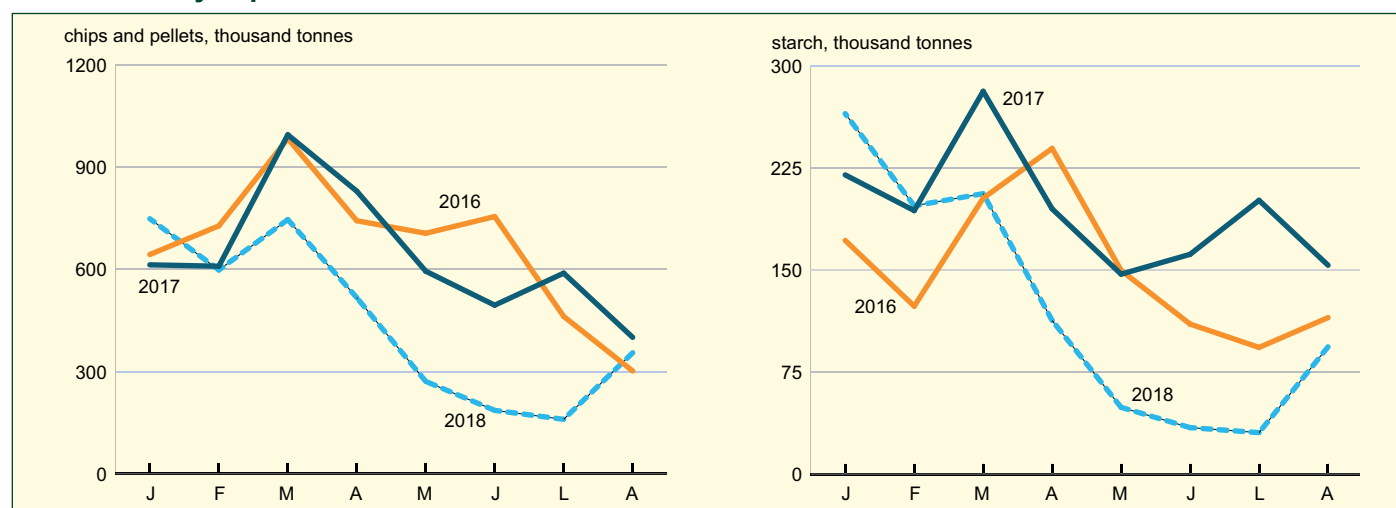
World imports of cassava

	2014	2015	2016	2017	2018*
(thousand tonnes)					
Total	17,380	21,444	21,260	22,081	13,550
Flour and Starch	7,554	8,497	9,375	9,577	7,030
Japan	916	851	884	980	900
China	3,813	4,205	4,922	5,535	4,000
Indonesia	888	1,256	1,339	752	730
Malaysia	525	586	580	622	600
Others	1,412	1,600	1,650	1,688	800
Chips and Pellets	9,826	12,947	11,885	12,504	6,520
China	8,651	10,533	8,725	8,923	4,350
Thailand	650	1,704	2,537	2,890	1,800
South Korea	517	310	323	262	220
Others	9	400	300	429	150

* Forecast

SOURCE: FAO (2018)

China's montly imports of cassava



Source: FAO (2018)



A truck prepares to transport cassava root to Thailand from Thma Puok District in Banteay Meanchey Province in northwest Cambodia in November. The district borders the eastern Thai provinces of Sakeo and Buriram.

PHOTO: CHOM SOK

that use modified starches — were meanwhile expected to decline 23 percent over the same period. “The hike in benchmark quotations of this product has accorded maize starch improved competitiveness, lowering international demand for its cassava counterpart,” the FAO said. Among major starch buyers, China is forecast to import 4 million tonnes in 2018, down 28 percent. Smaller declines are expected for imports by Japan, Indonesia and Malaysia (see bottom table on page 43).

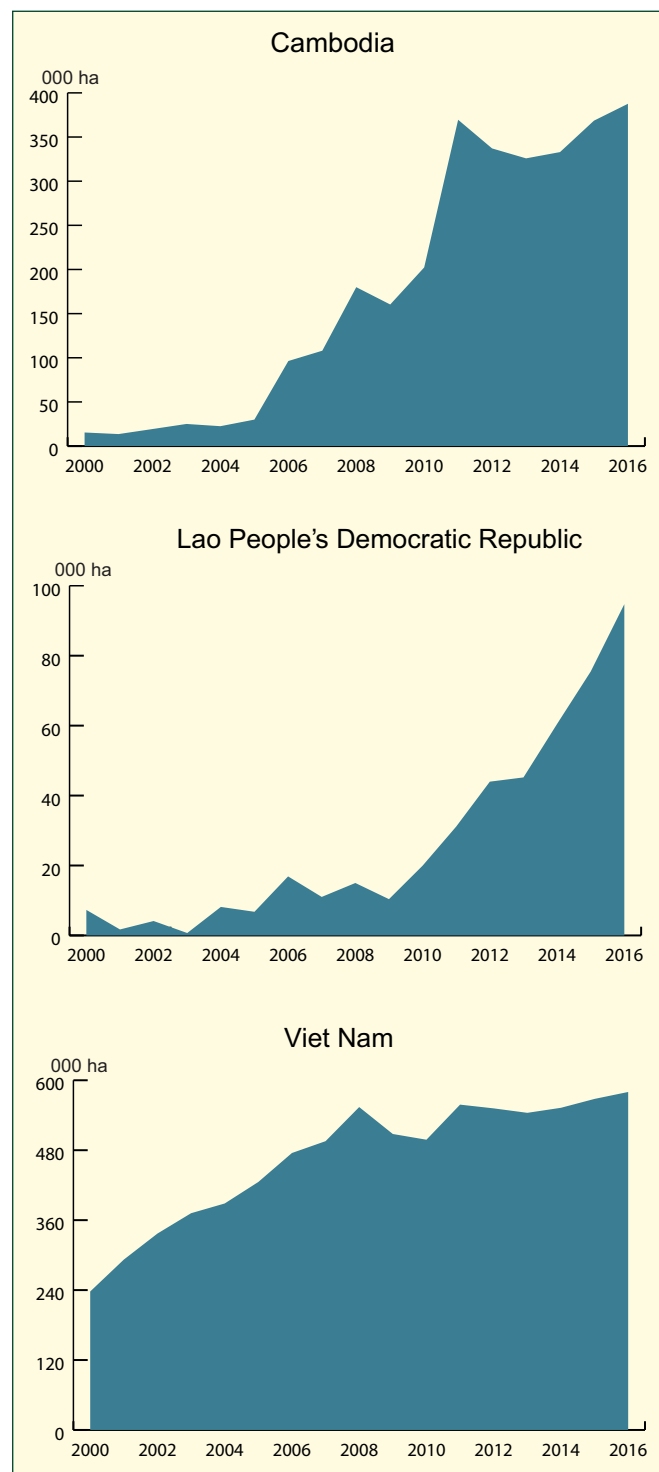
Where does this leave Cambodian, Lao and Vietnamese farmers? According to the FAO, the expansion of land used to grow the shrub for its tuberous root in these three countries reached 1.1 million ha in recent years. “Cambodia had a negligible cassava sector as recently as 2005, but by 2016 the country’s cassava area had reached close to 400,000 ha. Similarly, in just seven years, the cassava area in the Lao People’s Democratic Republic had increased from an insignificant level to almost 100,000 ha in 2016. Meanwhile, in Viet Nam, the area under cassava increased almost threefold between 2000 and 2016, to a level of 600,000 ha” (see charts).

'A quick shift to other remunerative crops to maintain their livelihoods could be the only alternative for cassava farmers, albeit not an easy one'

Such expansion has “often entailed wide-scale deforestation, encroaching on primary forests” and has “more than likely come at a considerable environmental cost, notwithstanding the loss of biodiversity,” the FAO said. “These factors aside, the prospect of a negative income impact on small-scale farmers who dominate cassava cultivation ... is a major concern.”

With average holdings of 4 ha, the UN agency estimated that more than 250,000 farmers were engaged in cassava cultivation in Cambodia, Lao PDR and Viet Nam. “These farmers have little or no recourse to safeguard mechanisms such as safety nets.” it said. “While the likelihood of establishing markets in the short term beyond the monopsony of China remains bleak, a quick shift to other remunerative crops to maintain

Cassava area expansion

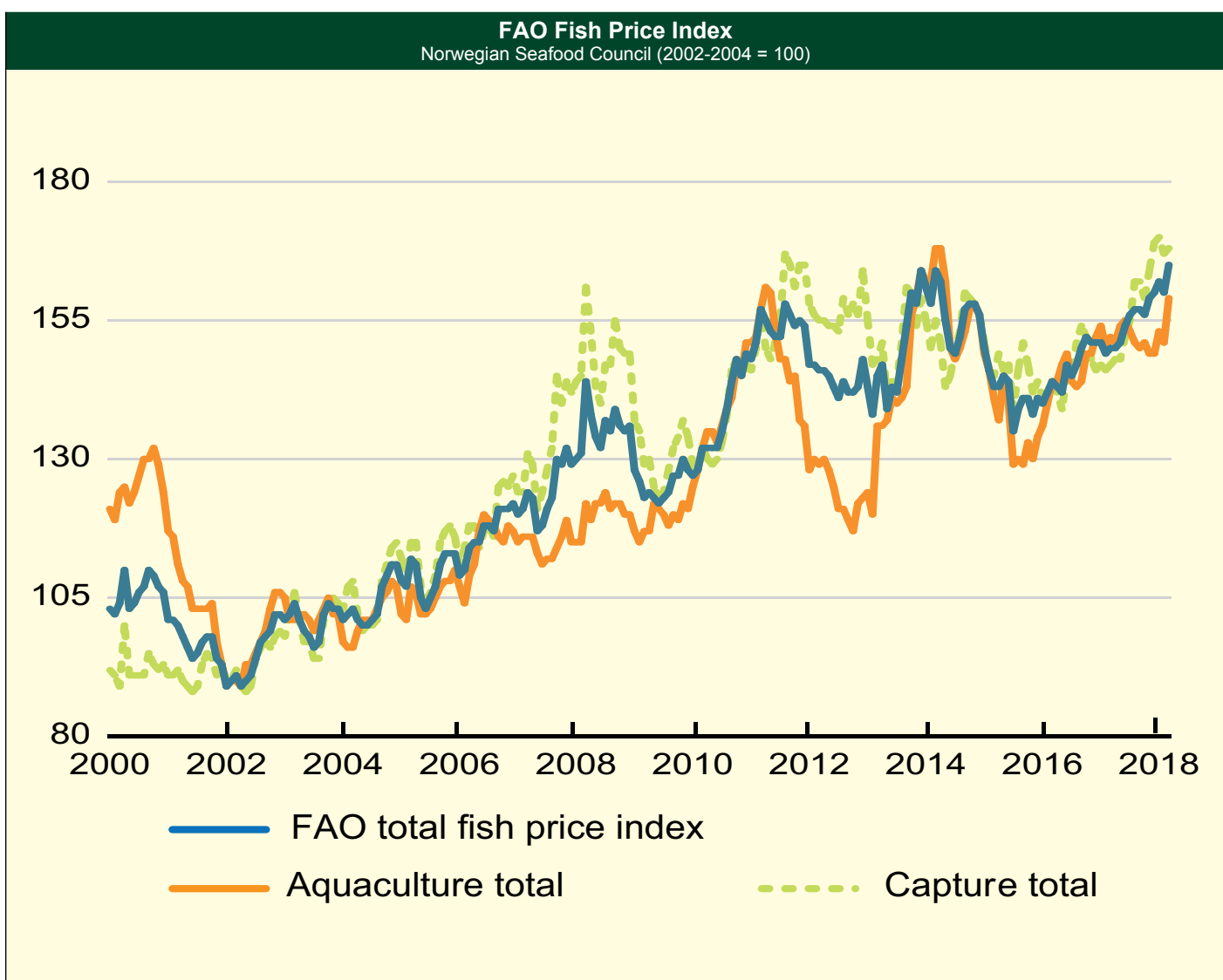


SOURCE: FAO (2018)

their livelihoods could be the only alternative for cassava farmers, albeit not an easy one.”

Further reading

FAO. 2018. Food Outlook - Biannual Report on Global Food Markets – November 2018. Rome. 104 pp. Licence: CC BY-NC-SA 3.0 IGO.



Production, trade, utilisation and consumption <small>FAO Food Outlook, October 2018</small>	2016	2017 Estimate	2018 Forecast	Change 2018/2017
	Million tonnes			%
Production	170.9	175.1	178.8	2.1
Capture fisheries	90.9	91.5	91.8	0.3
Aquaculture	80.0	83.6	87.0	4.0
Trade value (exports USD billion)	142.5	153.2	164.7	7.5
Trade volume (live weight)	59.5	60.5	60.8	0.5
Total utilisation	170.9	175.1	178.8	2.1
Food	151.2	154.5	157.9	2.2
Feed	14.6	15.6	15.8	1.4
Other uses	5.1	5.1	5.1	0.0
Consumption per person				
Food fish (kg/yr)	20.3	20.5	20.7	1.1
From capture fisheries (kg/year)	9.5	9.4	9.3	-1.0
From aquaculture (kg/year)	10.7	11.1	11.4	2.9
FAO Fish Price Index (2002-2004 = 100)	2016	2017	2018	Change
	146	154	Jan-July 160	Jan-July 2018/Jan-July 2017 5.6

Thailand Talaad Thai Wholesale Market, Pathum Thani Province	THB per kg	
	August, 2018	November, 2018
Slender rasbora (<i>Rasbora daniconius</i>)	--	--
Chinese edible frog (<i>Hoplobatrachus rugulosus</i>) (large)	85 - 90	90 - 100
Chinese edible frog (<i>Hoplobatrachus rugulosus</i>) (small)	75 - 80	80
Asian redtail catfish (<i>Hemibagrus wyckioides</i>)	180 - 230	120 - 190
Yellow mystus (<i>Hemibagrus filamentus</i>)	100 - 120	100 - 120
Tire track eel (<i>Mastacembelus favus</i>)	200 - 230	200 - 230
Clown featherback (<i>Chitala ornata</i>)	100 - 230	100 - 220
Iridescent mystus (<i>Mystus multiradiatus</i>) (large)	85 - 100	85 - 100
Iridescent mystus (<i>Mystus multiradiatus</i>) (small)	65 - 75	50 - 65
Wallago (<i>Wallago attu</i>) (large)	180 - 190	180 - 190
Wallago (<i>Wallago attu</i>) (small)	120	120
Bronze featherback (<i>Notopterus notopterus</i>)	80 - 100	80 - 190
Wild striped snakehead (<i>Channa striata</i>) (large)	120 - 125	120
Wild striped snakehead (<i>Channa striata</i>) (small)	80 - 85	80 - 90
Farmed giant snakehead (<i>Channa micropeltes</i>) (large)	90 - 95	90 - 95
Farmed giant snakehead (<i>Channa micropeltes</i>) (small)	80 - 85	80 - 85
Bighead walking catfish (<i>Clarias macrocephalus</i>) (large)	100 - 110	100
Bighead walking catfish (<i>Clarias macrocephalus</i>) (small)	100	85 - 100
Farmed North African walking catfish hybrid (<i>Clarias</i> spp.) (large)	35 - 37	42 - 45
Farmed North African walking catfish hybrid (<i>Clarias</i> spp.) (small)	35 - 38	45 - 48
Siamese red catfish (<i>Phalacronotus bleekeri</i>) (large)	300	380
Siamese red catfish (<i>Phalacronotus bleekeri</i>) (small)	120 - 180	130
Silver barb (<i>Barbonymus gonionotus</i>) (large)	50 - 55	50 - 55
Silver barb (<i>Barbonymus gonionotus</i>) (small)	30 - 35	30 - 35
Red tilapia hybrid (<i>Oreochromis</i> spp.) (large)	80 - 90	80 - 90
Red tilapia hybrid (<i>Oreochromis</i> spp.) (small)	65 - 70	65 - 70
Nile tilapia (<i>Oreochromis niloticus</i>) (large)	45 - 55	45 - 55
Nile tilapia (<i>Oreochromis niloticus</i>) (small)	25 - 35	28 - 35
Whisker sheatfish (<i>Kryptopterus</i> spp.) (large)	130 - 150	350
Whisker sheatfish (<i>Kryptopterus</i> spp.) (small)	90 - 100	200
Common carp (<i>Cyprinus carpio</i>) (large)	32 - 35	32 - 35
Mekong giant catfish (<i>Pangasianodon gigas</i>)	50 - 60	50 - 55
Boeseman croaker (<i>Boesemania microlepis</i>)	100 - 240	80 - 240
Horse-face loach (<i>Acantopsis choirorhynchos</i>)	150 - 160	120
Giant gourami (<i>Osphronemus goramy</i>)	80 - 90	80 - 90
Siamese mud carp (<i>Henicorhynchus siamensis</i>)	55 - 60	50 - 55
Snakeskin gourami (<i>Trichopodus pectoralis</i>)	100 - 175	100 - 200
Striped catfish (<i>Pangasianodon hypophthalmus</i>)	25 - 28	25 - 28
Climbing perch (<i>Anabas testudineus</i>) from rice paddy (large)	90 - 95	90 - 95
Climbing perch (<i>Anabas testudineus</i>) from rice paddy (small)	70 - 80	70 - 80
Farmed climbing perch (<i>Anabas testudineus</i>) (large)	90 - 95	90 - 95
Farmed climbing perch (<i>Anabas testudineus</i>) (small)	80 - 85	80 - 85
Spot-fin spiny eel (<i>Macrognathus siamensis</i>) (large)	140 - 150	150
Spot-fin spiny eel (<i>Macrognathus siamensis</i>) (small)	120 - 150	100
Rice-field eel (<i>Monopterus javanensis</i>) (large)	270 - 280	250 - 270
Rice-field eel (<i>Monopterus javanensis</i>) (small)	310 - 320	300
Pond snail (<i>Filopaludina martsensi</i>)	30 - 35	35 - 90
Viet Nam	VND per kg unless otherwise stated	
Vietnam Association of Seafood Exporters and Producers (VASEP), Dong Thap Province in the Mekong Delta except black tiger shrimp (Da Nang for individuals and Khanh Hoa Province for post larvae)	August, 2018	November, 2018
Pangasius (<i>Pangasianodon hypophthalmus</i>) (white flesh)	28,000 - 30,000	35,000 - 36,500
Pangasius fry (<i>Pangasianodon hypophthalmus</i>)	3 - 5 each	3 - 5 each
Pangasius sub-fingerlings (<i>Pangasianodon hypophthalmus</i>) (3,000/kg)	250 each	150 each
Pangasius fingerlings (<i>Pangasianodon hypophthalmus</i>) (28 - 32/kg)	900 - 1,200 each	1,100 - 1,200 each
Red tilapia (<i>Oreochromis</i> spp.) > 300g - 1,000g	37,000 - 38,000	36,000 - 38,000
Red tilapia fingerlings (<i>Oreochromis</i> spp.) (80/kg)	300 - 320 each	300 - 320 each
Snakehead (<i>Channa</i> spp.) ≥ 500g	34,000 - 37,000	36,000 - 40,000
Snakehead fry (<i>Channa</i> spp.) (1,200/kg)	110 - 140 each	110 - 140 each
Snakeskin gourami (<i>Trichogaster pectoralis</i>) (6/kg)	35,000 - 37,000	40,000 - 60,000
Climbing perch (<i>Anabas testudineus</i>) (3 - 5/kg)	30,000 - 32,000	33,000 - 35,000
Japanese wrinkled frog (Thai strain) (<i>Glandirana rugosa</i>) (3 - 5/kg)	40,000 - 44,000	40,000 - 45,000
Japanese wrinkled frog (Thai strain) fry (<i>Glandirana rugosa</i>) (120 - 140/kg)	600 - 750 each	600 - 750 each
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) (>100g)	260,000 - 280,000	210,000 - 250,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) (75g - 99g)	220,000 - 240,000	180,000 - 200,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) (50g - 74g)	150,000 - 170,000	120,000 - 150,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) (berried females, inferior old blue-claw males)	90,000 - 100,000	80,000 - 900,000
Giant freshwater prawn post larvae (<i>Macrobrachium rosenbergii</i>) (80,000 - 90,000/kg)	120 - 140 each	120 - 140 each
Black tiger shrimp (<i>Penaeus monodon</i>) 15/kg	460,000	440,000
Black tiger shrimp (<i>Penaeus monodon</i>) 25 - 30/kg	210,000	250,000
Black tiger shrimp (<i>Penaeus monodon</i>) 40/kg	145,000	220,000
Black tiger shrimp post larvae (<i>Penaeus monodon</i>) (15 days)	600 - 800 each	650 - 700 each



PHOTO: CHHUT CHHEANA

Stationary bagnets, known as *dai*, across the Tonle Sap River in Cambodia's Kandal Province at the beginning of the 2018-19 season on October 21. The *dai* fishery is the biggest commercial fishery in the Mekong Basin and targets fish migrating out of the Tonle Sap Lake.



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