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Cover: Taking a fin clip from a Nile tilapia (*Oreochromis niloticus*) exposed to the tilapia lake virus


PHOTO: TRINH QUOC TRONG

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Scientists and engineers outline measures to address sinking land in Mekong Delta

The World Bank recently highlighted the need for Viet Nam's 'strong coordination' with other Mekong Basin countries to address land subsidence in the delta (see *Catch and Culture-Environment*, Vol 28, No 2). A group of scientists has reached a similar conclusion, suggesting that institutions like the World Bank, the Asian Development Bank (ADB) and the Mekong River Commission (MRC) are well positioned to address what's causing delta land to subside. In an article published earlier this year, they propose six measures to save the delta from drowning.

Before the late 20th century, the Mekong River delivered an estimated 140 to 160 million tonnes of sediment to the delta every year. More than half is now trapped in reservoirs upstream. The supply of suspended sediment to the delta from seasonal typhoons – about a third the delta's suspended sediment – is meanwhile falling as tropical storms shift north. Sediment load is further reduced by sand mining, estimated at 54 million tonnes a year in 2013. At the same time, groundwater pumping has emerged as the main contributor to land subsidence. In 2017, a study by Dutch scientists – working with colleagues from the Division of Water Resources Planning and Investigation for the South of Vietnam in Ho Chi Minh City – found that groundwater extraction had caused the delta to sink by about 18 cm over the previous 25 years. It estimated the average rate of subsidence at 1.1 cm a year, with some areas sinking more than 2.5 cm.

In such a worst-case scenario with no measures taken, scientists from Stanford University, the University of California, Berkeley and the Polytechnic University of Milan have found that average relative subsidence could reach 1.8 m by 2100, submerging more than 90 percent of the delta. In the best-case scenario – with reduced water pumping, sand mining and dam building – subsidence would fall to 0.15 m, inundating about 10 percent of the delta. Maintaining sediment supply from the rest of the Mekong Basin was found to be “crucial” under all scenarios.

The study – published in the *Proceedings of the National Academy of Sciences of the United States of America*

last year – noted that subsidence wasn't unique to the Mekong Delta. Others sinking as a result of reduced sediment from upstream, unsustainable delta management and sea-level rise include the Irrawaddy Delta in Myanmar and the Ganges-Brahmaputra Delta in Bangladesh and India along with the Nile Delta in Egypt and the Mississippi Delta in the United States.

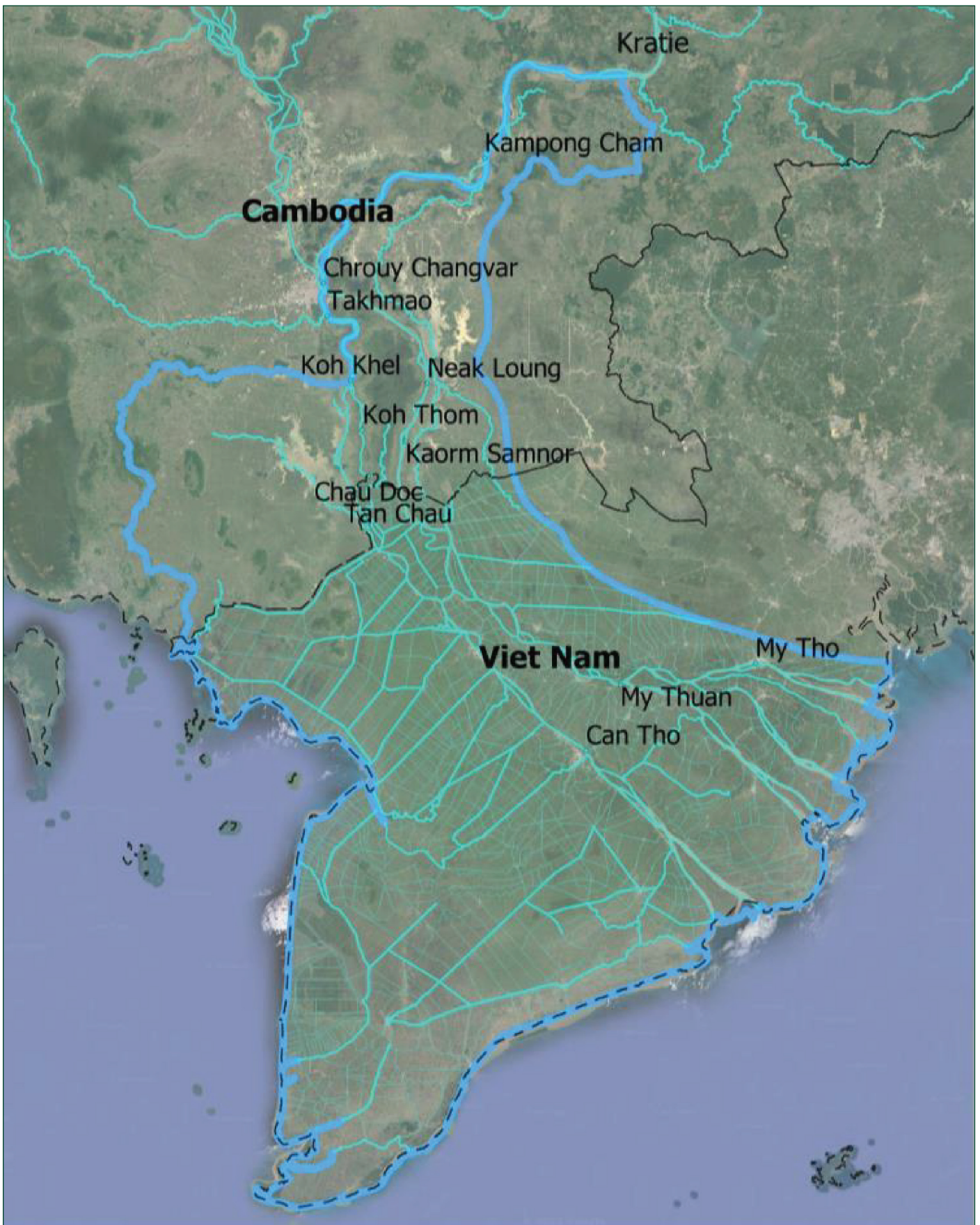
Four of the authors of that paper have since teamed up with 17 colleagues – including three Vietnamese and a Cambodian – to propose measures to safeguard the delta. According to their article, published in the journal *Science* in May, more sediment is needed in the delta to combat rising sea levels. “Only improved coordination of governance and investments, informed by science, will provide the delta with those critical resources,” the article says.

But turning their six proposals into impactful decisions will require political will and coordinated actions at both national and regional levels. “Although some drivers of subsidence can be influenced by local and national actions, others will require interventions coordinated between Cambodia and Vietnam, and throughout the entire basin from which the essential water and sediment resources are derived,” the authors state. At the same time, some activities like overpumping, sand mining and hydropower development “may need to be limited or gradually phased out despite their political importance and economic interests.”

Six possible measures

The six proposals are to avoid high-impact dams, pass sediment through or around dams, phase out riverbed sand mining, transform delta agriculture, maintaining delta connectivity and leverage nature-based coastal protections. According to the authors, the measures are not without global precedents (see table on page 6). But most have been at smaller scales, highlighting the need for better environmental governance and innovative financial mechanisms to make integrated management feasible in the Mekong Basin.

Dam sites with the highest sediment-trapping potential should be avoided, the authors say, recommending optimal dam placement to minimise impacts while maintaining hydropower production. Also recommended are



Mekong Delta

Map: MRC



Six measures: enablers, precedents and roadblocks

Measure	Scale	Enablers	Precedents	Roadblocks
AVOIDING HIGH-IMPACT DAMS	WHOLE BASIN	Non-hydropower renewables and regional power grids enable foregoing high-impact dams while reaching climate goals	Moratorium on mainstream hydropower, canceling of high-impact dams, national strategic planning processes throughout region (e.g. Cambodia, Malaysia, Myanmar)	Hydropower export plans; lack of incentives, safeguards and compensation to forego high-impact dams
INCREASING SEDIMENT PASSAGE THROUGH EXISTING DAMS		Non-hydropower renewables increase dam operational flexibility	Sediment passage through dams through well-tested operational and structural measures	Measures to increase sediment passage can reduce power generation. High sediment releases at baseflow can negatively impact water users & ecosystems; retrofits and reoperation costly
CONTROLLING AND PHASING OUT RIVERBED SAND MINING		Alternative sourcing; circular sand economy, fewer concrete-heavy buildings	Riverbed mining phased out in many countries or limited to sustainable rates, replaced with aggregate from alternative terrestrial sources	Lack of business case, cost-benefit analyses & policy incentives for economically competitive alternatives; revenues from sand export and land reclamation
ADAPTING FARM PRACTICES TO MINIMIZE GROUNDWATER EXTRACTION	DELTA AND COAST	Precise and locally adopted agriculture and aquaculture to increase 'crop per drop'	Sustainable Groundwater Management Act (California) increases regional regulatory oversight while providing resources for better practices to agriculture and domestic users	High-intensity rice cropping and aquaculture requires systemic shifts in agricultural production
MAINTAINING FLOODPLAIN CONNECTIVITY		Certification of 'delta friendly' agriculture increases incentives for better sectoral sediment management	Artificial sediment splays and controlled flooding now applied (e.g. in Mississippi (and Ganges-Brahmaputra deltas) to increase sedimentation	Increasing floodplain infrastructure and three rice crops per year disconnect floodplains
LEVERAGING NATURE-BASED SOLUTIONS FOR COASTAL PROTECTION		International donors and local planners shift priorities from grey to green infrastructure	Successful coastal protection with nature based solutions (Viet Nam, Florida, New York); adaptation of shrimp farming-forestry enterprises in Viet Nam	Existing wetland and mangrove forests are destroyed or degraded for other uses. Lack of sediment decreases effectiveness of nature-based solutions (e.g. mangroves) to protect coastlines and build land

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sustainable sediment management strategies for existing and new dams such as sluicing, flushing, and bypasses to allow some sediment to move from upstream to downstream – as included in MRC’s Preliminary Design Guidance for Proposed Mainstream Dams in the Lower Mekong Basin in 2009.

To reduce the impact of sand mining, the authors recommend better enforcement of mining regulations, limiting extraction to a sustainable fraction of remaining sediment load and encouraging alternative con-

struction materials.

To address groundwater pumping and reconnect Mekong distributaries to the floodplain, the authors propose changes in farming practices in line with the Vietnamese government’s resolution on sustainable and climate-resilient development of the delta adopted in 2017. This would involve shifting to less water-intensive crops improving access to surface water, regulating water demand and reusing water.

The authors also recommend adapting water infrastructure to allow sediment-charged flows to spread across the delta at least one year in three and to prevent dikes cutting off canals from the floodplain. Finally, they highlight the importance of mangroves and wetlands as a low-cost solution to coastal erosion. But “there must be a supply of sediment for them to trap.”

Fundamental changes

In addition to the six specific measures, the authors propose three “fundamental changes” including getting investors to register and address impacts of their investments – on land subsidence, for example. At the same time, they say, civil society groups and investors should leverage their shared interests in making basin-scale change and scientists should communicate more clearly with decision makers about broad scientific consensus on key concerns.

‘Cooperation yields greater benefits than unilateral action’

“Existing transboundary organizations must play a key role,” the article says. “Although the MRC is unlikely to gain binding power to make strategy development decisions, it needs to strengthen its role as knowledge broker and amplifier of transboundary environmental issues ... including demonstrating that cooperation yields greater benefits than unilateral action ... Such information will be crucial to hold private and government investors accountable for the externalities of their investments.”

Raising awareness

Institutions like the World Bank, the ADB and other international organizations are already positioned to evaluate the strategic impacts of investments. “Their commitment to strategic and systems solutions can further awareness among national actors,” the article says. “They are well positioned to support sectoral reforms and highlight the role of strategic assessments and sustainable use of riverine resources.”

‘The Mekong Delta can only exist if it receives a constant sediment supply from its upstream basin and water flows to spread that sediment’

The authors argue that such organizations and actors need to “broaden their scope” from a narrow focus on developing water and energy resources to consider other sectors – like the food and construction industries – and holistic solutions to address the subsiding delta. “Implementing those solutions could make the

Mekong Delta a sentinel of integrative and innovative delta management and climate adaptation, rather than being drowned by the century’s end,” they conclude.

“It’s hard to fathom that a landform the size of the Netherlands and with a comparable population might disappear by the end of the century,” said co-lead author Matt Kondolf, Professor of Landscape Architecture and Environmental Planning at University of California, Berkeley. “Yet, like any river delta, the Mekong Delta can only exist if it receives a constant sediment supply from its upstream basin and water flows to spread that sediment across the delta surface (and) build land at a rate that is equal or greater than global sea level rise.”

Co-author Susanne Schmeier, Associate Professor in Water Law and Diplomacy at the IHE Delft Institute for Water Education in the Netherlands, reiterated the need for coordinated transboundary approaches. “Efforts by national governments, regional organizations and international actors, such as development agencies and banks, as well as the private sector and civil society, are all needed if the Mekong delta is to have a chance,” she said. “We need basin-wide transboundary, fast and concerted cooperation among all partners.”

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Mekong Aquatic Animal Production and Research Centre inaugurated in Cambodia

New centre aims to promote aquaculture and conservation of aquatic species in Cambodia's northeast

Cambodia inaugurated a centre to advance aquaculture in northeastern provinces on August 10. Located in Sesan district in Stung Treng province, the USD 1.8 million Upper Mekong Aquatic Animal Production and Research Centre was funded by a concessional loan from the World Bank. The Royal Government of Cambodia also contributed financially to the construction of the first-ever centre of its kind in the area.

Addressing the inauguration ceremony, Agriculture, Forestry, and Fisheries Minister Veng Sakhon underlined that the centre was essential to ensure food security through fish farming and aquaculture for domestic supply and export. The centre will play a key role in

promoting and preserving aquatic species and provide training in aquatic breeding and raising techniques and conserving aquatic species. It will also contribute to improving the efficiency of the management of fishery resources in the Upper Mekong, he said.

The centre is equipped for administration, research and laboratory facilities, as well as training, fish breeding, hatchery and rearing activities. Located on the Sekong River, a major tributary of the Mekong that rises in Viet Nam and flows through Lao PDR before reaching Cambodia, the centre covers a 10.4 ha site. It has 24 ponds — a large pond for storing water, 12 ponds for fingerlings, six for breeding, four for grow-out, a wastewater and water treatment pond.

The minister said the centre was a "timely response to the need to improve the efficiency of fisheries resource



Veng Sakhon addresses the opening ceremony

PHOTO: CHHUT CHHEANA / WONDERS OF THE MEKONG



Cambodian Red Cross Youth attending the opening ceremony

PHOTO: CHHUT CHHEANA / WONDERS OF THE MEKONG

management” in the region. “In a situation where the world is facing a food crisis due to the war between Russia and Ukraine, the centre will surely play an important role in ensuring food security through family fish farming and aquaculture to supply local and foreign markets,” he said. “All localities and the livelihoods of the people, especially ethnic minorities, will gradually improve while protected and endangered fish species will be once again found in lakes, streams and rivers.”

World Bank Country Manager Maryam Salim said the centre would produce three million fingerlings a year and provide better services to fish farmers. It will also become an important research and innovation hub for high-value fish species, she said.

Officials from the Ministry of Agriculture, Forestry and Fisheries and the Ministry of Economy and Finance attended the opening along with Cambodian National Mekong Committee (CNMC) Permanent Vice Chair-

man Te Navuth and Secretary General So Sophort, and local officials from Stung Treng and other provinces in the northeast, namely Kratie, Mondulkiri and Ratanakkiri.

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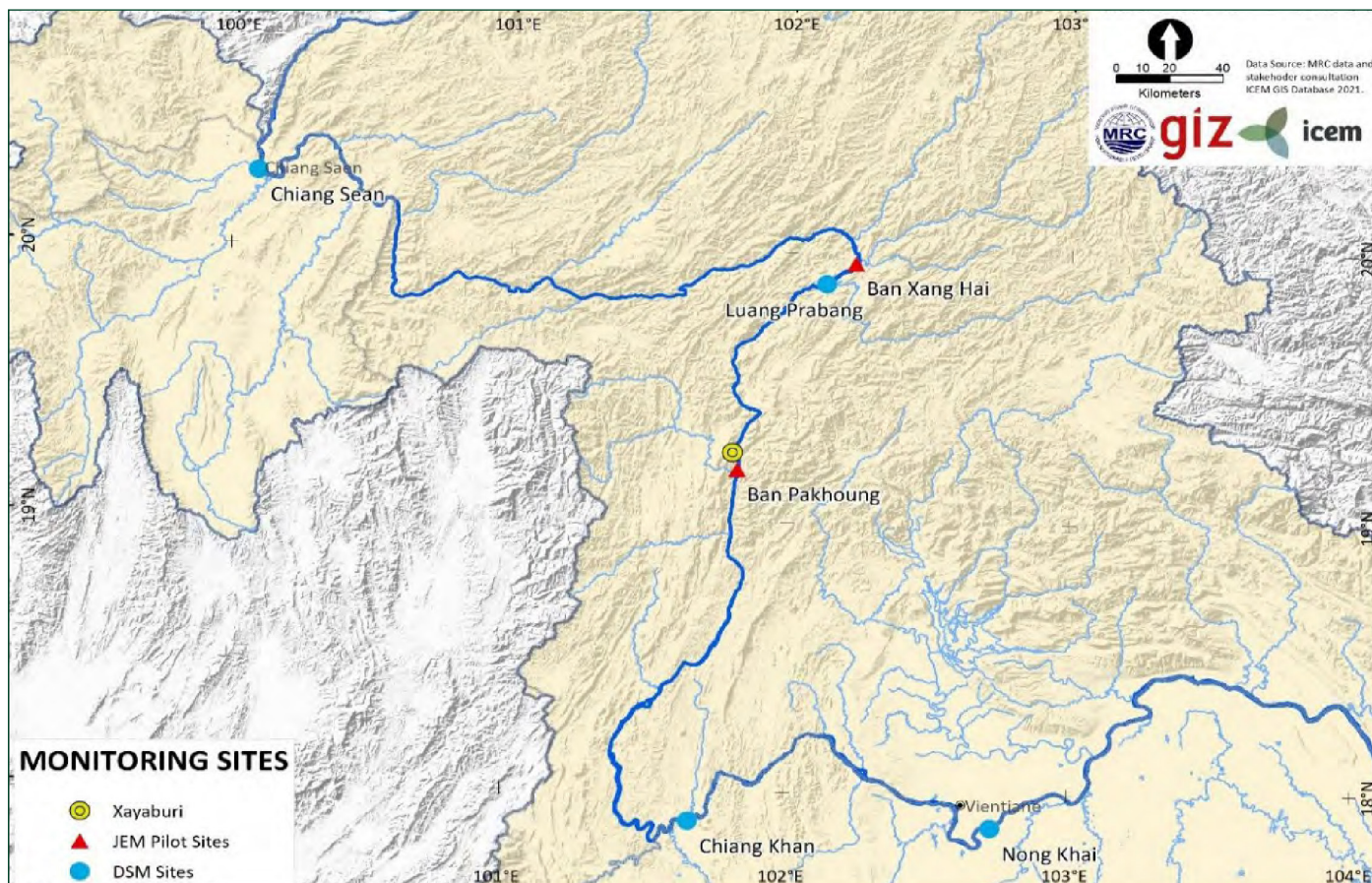
MRC releases results of pilot monitoring around Xayaburi and Don Sahong dams

Preliminary findings of Joint Environmental Monitoring (JEM) programme are now available in a 770-page report covering hydrology, sediment, water quality, aquatic ecology and fisheries

The first two mainstream hydropower projects on the Lower Mekong have had “measurable, but moderate” impacts on water flow, sediment and fisheries, according to preliminary findings of report released by the Mekong River Commission (MRC) in August, 2022. The final report on pilot projects undertaken by the MRC’s Joint Environmental Monitoring (JEM) programme covers the Xayaburi dam, about 100 km downstream from the northern Lao city of Luang Pra-

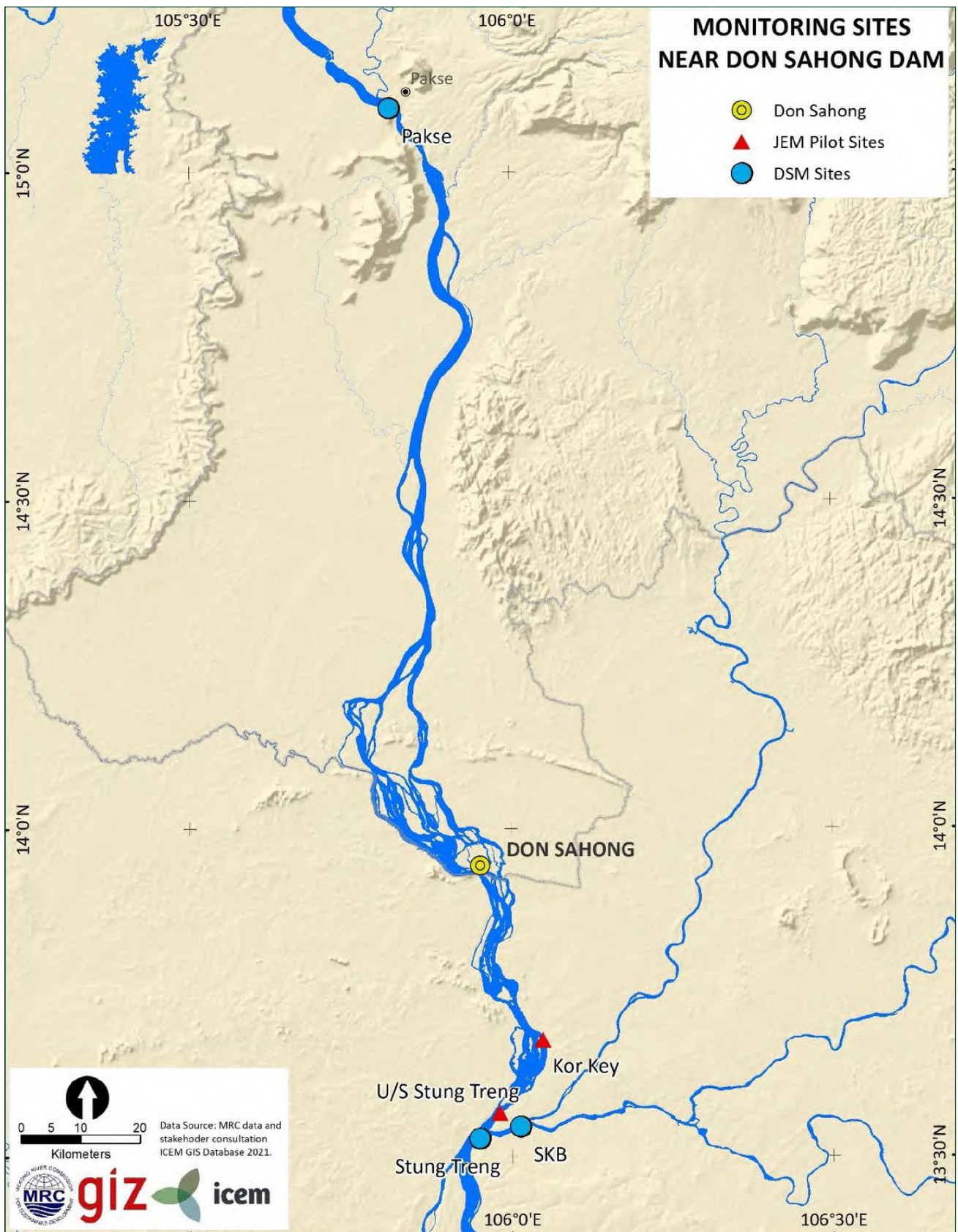
bang, and the Don Sahong dam, located on a channel of the Mekong in the southern Lao province of Champassak near Cambodia. Field monitoring by the JEM programme was mainly during the dry season between 2020 and 2021. In addition to hydrology, sediment and fisheries, the monitoring covered water quality and ecological health.

“It’s still very early in the process to draw any conclusions,” the MRC Secretariat said in a statement accompanying the release of the report in August, 2022. But by testing protocols around Xayaburi and Don Sahong, “the MRC aims to create monitoring methods and standards that all hydropower operators on the Mekong mainstream will follow in the future.”



Hydrology and sediment monitoring sites around the Xayaburi hydropower plant in northern Lao PDR. Blue circles indicate discharge and sediment monitoring sites that existed before the JEM pilot projects. Red triangles indicate two new monitoring sites – a manual water-gauge station at Ban Xanghai and an automatic Hydrological Cycle Observing System (HYCOS) station at Ban Pakhoung.

SOURCE: MRC (2022b)



Hydrology and sediment monitoring sites around the Don Sahong hydropower plant in southern Lao PDR and northern Cambodia. Blue circles indicate discharge and sediment monitoring sites that existed before the JEM pilot projects. Red triangles indicate two new monitoring sites – an automatic Hydrological Cycle Observing System (HYCOS) station and a water quality monitoring station downstream from the Don Sahong power station and a second HYCOS station upstream from the Cambodian town of Stung Treng, located at the confluence of Mekong and Sekong rivers..

SOURCE: MRC (2022b)



Hydrology

Among the most significant findings of the JEM pilot projects was that overall river flow patterns did not change. Upstream from Xayaburi, water levels at Luang Prabang showed small daily fluctuations associated with hydropower operations. Immediately downstream from the dam, water levels at Ban Pakhoung showed large fluctuations during low and moderate flows. But these did not persist further downstream at Chiang Khan (see map on page 18). Upstream from Don Sahong, small fluctuations at Pakse were related to hydropower operations in Mekong tributaries. At the downstream site of Koh Key in Cambodia, monitoring showed no fluctuations related to hydropower (see map on page 19).

Sediment

For sediment downstream from Xayaburi, concentrations and loads were found to have fallen “substantially” since 2018. This may reflect increased sediment trapping by tributary hydropower projects and the Xayaburi project. “But a longer record of results is required to confirm this observation,” the report said. The decrease in suspended sediment concentrations was found to be larger than that attributed to flow conditions alone. At Don Sahong, the report said the project operator had presented monitoring results showing “some reduction in turbidity” at the start of

the wet season reflecting sediment being trapped in the impounded reservoir.

Fisheries

For Xayaburi, data consistently showed reductions in biodiversity of 40 to 60 percent at most sites, indicating that some species had become too rare to be recorded in catches. “This pattern was somewhat expected,” the report said, referring to the impacts of the hydropower project and human pressures on the river. “However, the extent and speed of change seem extremely high.” For Don Sahong, monthly catch data were mixed with a significant increase upstream from the hydropower station, a progression downstream and a sharp decline further downstream in Cambodia. The higher catches recoded at the Lao monitoring sites were in contrast to interviews of fishers based on local ecological knowledge.

Water quality

Water quality at Xayaburi and Don Sahong was generally good with concentrations of measured parameters within the thresholds of MRC guidelines for the protection of human health and aquatic life. No evidence of stratification was found in the reservoirs. This can occur if the upper and lower layers of water are not mixed and become separated by temperature differences. Poor water quality in the bottom layers of a stratified



The Khone Falls area on the Mekong River in southern Lao PDR. Major waterfalls are shown in blue and major islands in yellow. Channels improved by Don Sahong Power Co Ltd to encourage fish swimming upstream from Cambodia to complete their migration are shown in orange.

SOURCE: MRC (2022b)



Don Sahong hydropower dam in southern Lao PDR

PHOTO: MRC

reservoir favors more tolerant benthic fauna and deters most fish species.

Ecological health

Upstream from both Xayaburi and Don Sahong, ecological health indicators showed “good” conditions. At the impoundment areas and immediately downstream from both hydropower stations, indicators showed “moderate” conditions. This reflected habitat changes and sedimentation in the impoundments as well as changing substrate conditions and fluctuating water levels and flows downstream. But the indicators showed evidence of recovery 10 km downstream from the dam sites.

‘It’s too early to attribute every impact to the dams’

Given that findings were drawn from one monitoring cycle, the JEM team suggested monitoring over the next two to three years to draw strong conclusions about the impact of hydropower development and other human pressures.

“We must understand the scope of our challenges, and identify the most effective methodology to measure it,” said MRC Secretariat Chief Executive Officer Dr Anoulak Kittikhoun. “While this report sheds some light on the impact of hydropower, it’s too early to attribute every impact to the dams. Climate change and other developments are also factors.”

The statement by the Secretariat said the report was

likely to become a foundation for future policies and monitoring activities. Findings are expected to shape future hydropower projects and provide a basis for constructive discussions between riverine communities and MRC members – Cambodia, Lao PDR, Thailand and Viet Nam.

Recommendations

The report made more than a dozen recommendations to the MRC, Member Countries and hydropower operators. These included “targets or limits on the rate of water level change” in the Mekong mainstream. The report also recommended a central communication or notification system to alert downstream communities and countries of impending flow releases or other sudden changes. Other recommendations included jointly operating low-level gates for sediment transport and deepening entrances to fishways at Don Sahong and improving their channels (see map opposite).

For future hydropower projects, the report called for “systematic water monitoring during all phases of hydropower construction and operation, so that appropriate action can be taken if poor water quality conditions emerge.”

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Scientists seek **genetic solution** to tilapia lake **virus** after **outbreak in pond**

Area on chromosome of fish exposed to new virus has emerged as a ‘promising avenue’ to boost resistance through selective breeding based on genetic markers

In 2017, the Food and Agriculture Organization of the United Nations issued a global alert about a deadly new virus affecting Nile tilapia (*Oreochromis niloticus*), one of the world’s most widely famed fish species. First reported in Ecuador in 2013, the tilapia lake virus had spread to Israel, Colombia, Egypt and Thailand by 2017, with the potential to adversely affect global food security (see *Catch and Culture*, Vol 23, No 2). The virus has since been detected in other countries including Malaysia, where an outbreak in 2018 has been used to study if genetic markers can be used to improve resistance.

The outbreak occurred at a pond managed by WorldFish in the northern Malaysian town of Jitra as part of the international research group’s Genetically Improved Farmed Tilapia (GIFT) breeding programme, started with Philippine and Norwegian partners in 1988. The pond is located at the Jitra Aquaculture Extension Centre, operated by the Department of Fisheries of Malaysia’s Ministry of Agriculture and Food Industry.

Mortalities of 40 percent

Tilapias exposed to the virus came from the 16th generation of the GIFT strain amounting to 124 families produced by 124 females and 115 males. Before being transferred to the pond, 1,821 offspring around 110 days old were injected with microchips known as passive integrated transponder (PIT) tags. The microchips allow researchers to identify individual fish to keep pedigree records – around 86,000 going back to the first generation.

‘Signs of infection included skin erosion, bleeding and fin damage’

During the first five days of the outbreak that started in February, 2018, average mortalities were 56 fish a day. The number of deaths peaked at 128 fish after the tenth day, falling to 7 individuals on the fourteenth

day and zero on the eighteenth. Overall mortality was almost 40 percent for the entire population.

Throughout the outbreak, a veterinary expert observed clinical signs of tilapia lake virus disease among the affected fish. Signs of infection include skin erosion, bleeding and fin damage. Assessments of spleens in a sample of the fish confirmed the presence of the virus in 25 individuals. Of these, 16 had died and 9 had survived but tested positive. Another 9 survivors tested negative. Within the 124 families, deaths ranged from none of the offspring to all, suggesting genetic variation in resistance to the virus.

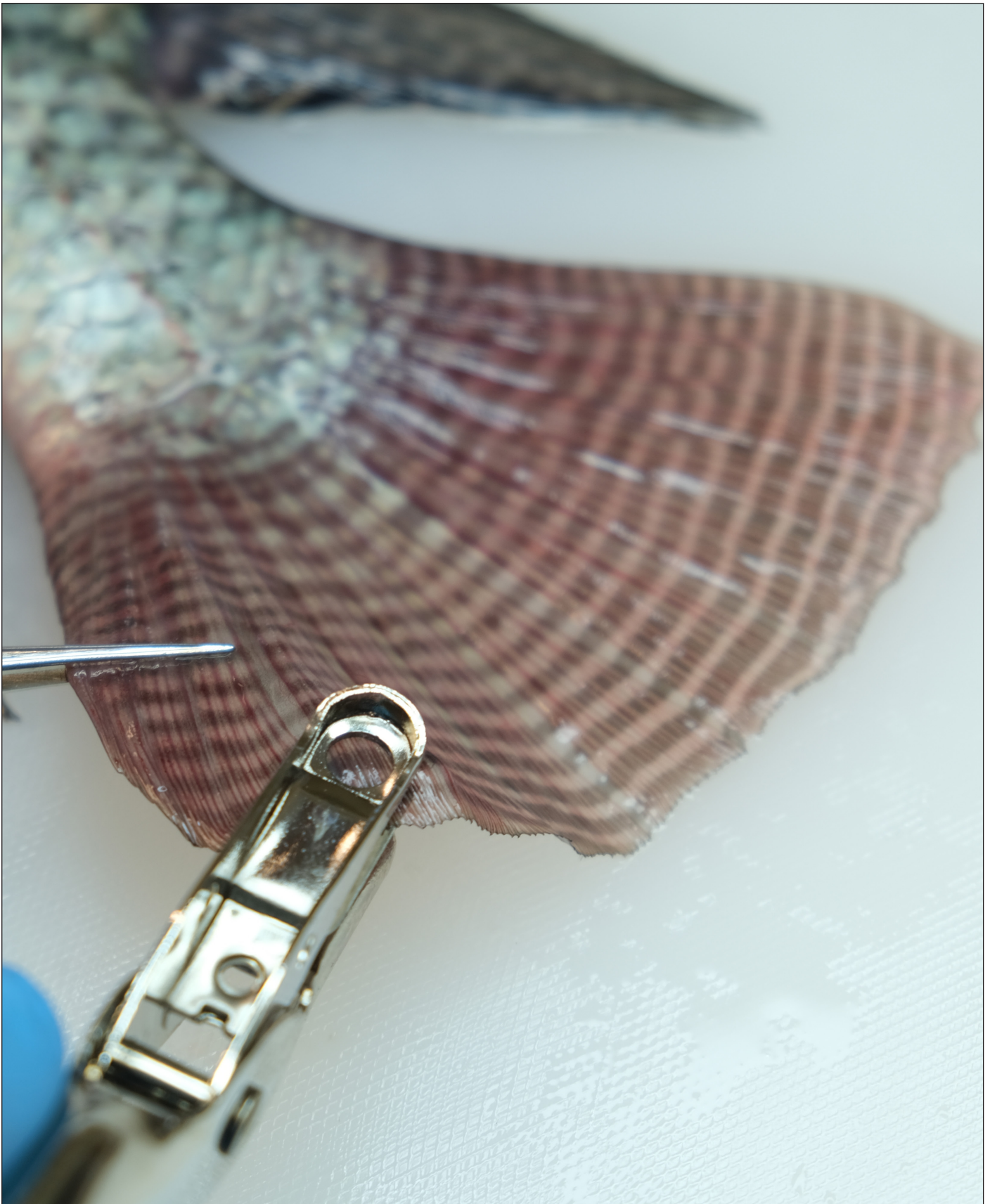
Rare finding on chromosome

Scientists from WorldFish and the Roslin Institute at the University of Edinburgh have since studied genotype and phenotype data for 950 of the offspring from 117 families (genotype is an organism’s genetic makeup whereas phenotype is its characteristics resulting from the genotype’s interaction with the environment). Published in the journal *Heredity* last year, the study also looked at the genotype data for 162 parents.

What they found was a high correlation to resistance to the virus on one of the tilapia’s chromosomes. This was located in small units of DNA known as single nucleotide polymorphisms (SNLs), which provide useful genetic markers between organisms. At the most significant SNL, average mortalities were only 11 percent for fish with signs of resistance to the virus but 43 percent for those indicating susceptibility.

‘The presence of such a major locus for a quantitative trait is rare in farmed animal breeding’

According to the study, the presence of such a major locus for a quantitative trait is rare in farmed animal breeding. “To date, most of the production traits of commercial interest in aquaculture have been found to be controlled by several loci with minor effects,” it said. A notable exception was a major quantitative trait locus (QTL) affecting resistance to infectious pancreatic necrosis virus in two populations of Atlantic salmon (*Salmo salar*). Marker-assisted selection has since re-



Before extracting DNA from fish, fins are clipped as illustrated above. In the Malaysian outbreak, fin clips were taken from all 1,821 fish collected from the pond. Fin clips from 195 parents were also taken. After quality control steps, including those to meet the criteria of the genotyping company in Ireland, the final number of fish from which scientists obtained genotype and phenotype data was 1,112 – 950 offspring and 162 parents.

PHOTO: TRINH QUOC TRONG



Dolly the Sheep: the world's first mammal cloned from an adult cell

The Roslin Institute, which has been studying genetic resistance to tilapia lake virus with WorldFish, has a rich history with livestock breeding going back to 1919. It came to world prominence in 1997 when it unveiled "Dolly the Sheep", the first mammal cloned from an adult cell. In this case, the cell was from the mammary gland of a six-year-old Finn Dorset sheep.

Dolly was born to a surrogate mother on 5 July 1996. After giving birth to six lambs between 1998 and 2000, she was infected by a virus causing lung cancer in sheep. The institute euthanised her in 2002 and donated her body to a local museum.



Dolly

PHOTO: ROSLIN INSTITUTE

"What made Dolly so special was that she had been made from an adult cell, which no-one at the time thought was possible," the institute says, noting that the first cloned mammal was a sheep cloned from an embryonic cell in Cambridge in 1984. The Roslin Institute started cloning sheep from embryonic cells in 1995, the year before Dolly was born.



Dolly doll for sale at Roslin Institute

PHOTO: TRINH QUOC TRONG

"Her birth proved that specialised cells could be used to create an exact copy of the animal they came from," the institute says. "This knowledge changed what scientists thought was possible and opened up a lot of possibilities in biology and medicine, including the development of personalised stem cells known as iPS cells."

Cloned fish

Chinese scientists similarly trace the development of stem cell research in China to the first cloning of a fish in 1963. That was when embryologist Tong Dizhou transferred DNA from the cell of a male Asian carp



Tong Dizhou

PHOTO: CHINESE ACADEMY OF SCIENCES

to the egg of a female Asian carp in 1963. According to scientists working on tissue engineering and stem cell research in Beijing, micro-organisms, worms and amphibians had already been cloned.

"But before Tong, nobody had ever managed to clone such a complex organism," they wrote in a paper published in 2007, noting that he later inserted the DNA of an Asian carp into the egg of a European crucian carp to create the first interspecies clone.

'Few, if any, Western scientists knew of Tong's achievements'

"Based on this pioneering research, Chinese scientists developed fish-breeding techniques so powerful that the nation now produces more than half of the world's aquaculture harvest," the authors said.

"But few, if any, Western scientists knew of Tong's achievements, partly because his work was published in a Chinese journal, *Acta Zoologica Sinica*, which did not have an English-language abstract, a common problem in non-Western scientific periodicals."

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An individual from the outbreak that tested positive for the tilapia lake virus

PHOTO: TRINH QUOC TRONG

sulted in outbreaks of this virus falling close to zero in Norway. “However, QTL of such large effect are rare,” the study said.

‘Promising avenue’

The effect of the locus on the tilapia chromosome is not as great as the one found on the chromosome of the Atlantic salmon. But the authors of the study conclude that it’s a “promising avenue” to reduce tilapia mortalities through selective breeding based on genetic markers. Marker-assisted selection could be done without additional data or in combination with experiments on relatives of the parents of the fish exposed in Malaysia.

‘Future studies are expected to focus on the causative gene and mutation for genome editing’

Compared with pedigree-based approaches to breeding, “the use of genetic markers together with family selection can achieve higher genetic gain,” the study says. Future studies are expected to focus on the causative gene and mutation for genome editing, seen as having significant potential to improve disease resistance in aquaculture species.

Resistance to tilapia lake virus is one of three traits World Fish is considering to make fish more resilient to

climate change in collaboration with the Roslin Institute along with Wageningen University in the Netherlands, Earlham Institute in the United Kingdom and the Agricultural Research Centre for International Development in France. The other two traits are tolerance of low dissolved oxygen conditions and improving feed conversion ratios by selecting for feed efficiency separate from growth, the most common trait targeted in selective breeding with fish.

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Catching eels at home in central Laos

Catching fish and other aquatic animals by hand is common in the Lower Mekong Basin. In Cambodia, for example, children take spades to rice fields in the dry season to open up cracks in the dried-out soil to look for frogs that are then collected by hand. Here we look at a technique for catching Asian swamp eels (*Monopterus albus*) by hand in the central Lao province of Xaysomboun.

When people talk about “fishing by hand” in Lao PDR, it can mean sticking your hand with a hook into the hole of an eel. Asian swamp eels (*Monopterus albus*) are called

ein in the Lao language, and have a long body similar to a snake, but without scales. They live in muddy areas such as swamps, marshes, ponds, and wetlands. Eels eat other aquatic animals and detritus. During the dry season, they create holes along riverbanks as habitats. A skilled fisher knows how to catch an eel in its home.

This fishing method draws on unique local knowledge by using small frogs (*Fejervarya limnocharis*) as bait. People hunt the frogs using lights at night. Eel fishing by hand occurs during the daytime. Unlike other types of fishing gear – such as basket eel traps and bamboo eel traps – it does not require too much waiting (not more than 30 minutes).



A rice field frog (*Fejervarya limnocharis*) used as bait (left) and a hooked swamp eel (*Monopterus albus*) emerging from a hole and being hauled in (right)

PHOTOS: SIPHON PHONEDABOUTDY/FISHBIO



Asian swamp eels can grow to 70 cm

PHOTO: SIPHON PHONEDABOUTDY/FISHBIO

When FISHBIO staff were on a gill net sampling survey, we saw fishers at Mouangsom village in Xaysomboun province using this technique.

Fishers, who are mostly teenagers, use floating hooks with nylon strings for this technique from the end of the rainy season to the dry season (October to May). During this time, there is less water in wetland areas, so eel holes are easier to access. The physical characteristics of an eel hole include a wet, round shape in the riverbank where turbid water occurs. It could be located in shallow water or in wet, muddy areas. In general, fishers search for a fresh hole where they believe an eel is living inside. Then, they hang a small frog on a hook and put it into the hole about 40 cm deep. They wait until the eel bites, then use their hands to take the fish out of the hole.

Usually fishers will try about 15 to 20 holes per day with this technique, and often catch about 5 to 10 eels per day, or about 1.5 to 2 kg. Eels can be used to cook special dishes like barbecued eel, tom yam soup, and spicy fried eel with a lot of herbs. If fishers catch many eels, they will sell them for about LAK 70,000 (\$8.50) per kg at the local market or in their own village. However, this technique is not too common in Lao PDR because the catch rate is low compared with basket and bamboo traps. And sometimes, unlucky fishers I guess wrong and put their bait into a crab hole instead – and may feel the pinch.

Source: FISHBIO Laos

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Slowing down fast fashion

A Chinese think tank examines an overlooked contributor to greenhouse gas emissions

In 2019, the *Wall Street Journal* reported some startling numbers about the global fashion industry. According to the newspaper, Americans were purchasing an average of 68 garments a year – about five times what they were buying in 1980. And of the estimated 80 billion items of clothing acquired worldwide every year, each were worn an average of only seven times before being thrown out. For Chinese, the newspaper said, the rate was just three times.

Welcome to “fast fashion”, the 21st century phenomenon that upended the business model of spring, summer, autumn and winter “collections” that once dominated the industry. “Whereas fashion used to be divided into four seasons, there are now as many as 52 with different clothes arriving every week at fast fashion stores,” says China Water Risk, a Hong Kong-based think tank that works with the private sector to address water and climate risks in China and across Asia.

In a report published earlier this year, the think tank identifies fast fashion as one of eight areas where consumers can change their daily habits to prevent two billion tonnes of greenhouse gas emissions – equivalent to the combined emissions of Japan and South Korea in 2015. The report’s recommendations included driving less, flying less and consuming less electricity, among the usual suspects for measures people can take to address climate change. They also include slowing down fast fashion. “While coal, oil and the energy sector in general have been called out as the bad boys of climate change, fashion has been flying under the radar,” it says.

‘If the fashion industry were a country, it would be the 4th largest emitter of carbon dioxide behind China, the US and India’

The think tank offers some sobering statistical comparisons. For example, the fashion industry’s carbon emissions of 1.75 gigatonnes in 2015 were not only more than the energy-related emissions of the aviation and shipping industry combined the same year (1.19 gigatonnes) but also exceeded those of Australia, Canada, France and the United Kingdom combined (1.61 gigatonnes). Moreover, the fashion industry’s emissions are

projected to reach 2.80 gigatonnes by 2030, up 60 percent from 2015 or 1.05 gigatonnes – more than the combined energy-related emissions of Hong Kong, Indonesia, Pakistan, Thailand and Viet Nam. “If the fashion industry were a country, it would be the 4th largest emitter of carbon dioxide behind China, the US and India,” the report says. To illustrate the point, the authors of the report calculate that the 2.1 kg of carbon emitted to produce a single cotton T-shirt is enough to charge a smartphone 286 times.

‘Cotton, a key staple of the industry, uses the equivalent of 12.5 bathtubs of water to make a T-shirt’

But carbon emissions are not the only problem. According to the report, the industry uses almost 80 billion m³ of water every year – 2 percent of the world’s total freshwater extraction and more than 10 percent of the water used by all types of industry. The raw material phase of production is especially water intensive. Cotton, a key staple of the industry, uses the equivalent of 12.5 bathtubs of water to make a T-shirt and 50 tubs to produce a pair of jeans. Natural fibres from livestock – like leather, cashmere and wool – are also water (and carbon) intensive.

“Fashion is also highly polluting,” the report says, noting that cotton growing has been estimated to account for 24 percent of the global sales of insecticides and 11 percent of pesticide sales. To make matters worse, untreated wastewater is often dumped into water sources near textile factories. “While those in Europe and US wear their brand new garments, the dirty byproducts are left in already water-scarce countries like China, India and Pakistan,” the think tank says.

Washing garments made from synthetic fibres like polyester also pollute waters by releasing hundreds of thousands of plastic microfibres. According to the report, more than a third of all microplastics in the ocean come from the laundering of synthetic fibres. Fashion accessories meanwhile add to the plastic waste. “Cheap sunglasses and fast fashion jewellery at basement prices mean an exponential increase in plastic waste ending up in landfills,” the report says.

To ease pressure on global greenhouse gas emissions, China Water Risk is not advocating a consumer

boycott of fast fashion. Instead, it urges consumers to consider slowing down with two “new fashion habits” — buying fewer clothes and wearing them longer. “We have chosen these because they are impactful and easily achievable and there is sufficient scientific research available to calculate emission cuts,” it says.

For example, it calculates that a person buying a pair of jeans and three T-shirts fewer every year would save 40 kg in greenhouse gas emissions. A person wearing a pair of jeans and three T-shirts nine months longer would save a further 12 kg. If 30 percent of American shoppers and 40 percent of European shoppers adopted such habits, the think tank estimates that almost 15 megatons could be saved — comparable to a third of Hong Kong’s emissions in 2015.

Out of fashion?

The European Commission has meanwhile come up with a strategy for “sustainable and circular textiles”, especially clothing – which accounts for more than 80 percent of the EU’s textile consumption. Released in March this year, the strategy deals directly with the fast fashion industry.

“The trends of using garments for ever shorter periods before throwing them away contribute the most to unsustainable patterns of overproduction and overconsumption,” it says. “Such trends have become known as fast fashion, enticing consumers to keep on buying clothing of inferior quality and lower price, produced rapidly in response to the latest trends.”

Goals of the strategy include “driving fast fashion out of fashion” whereby textile products sold in the EU are long-lived and recyclable, largely made of recycled fibres, free of hazardous substances and produced in respect of social rights and the environment by 2030. Under the EU vision, “consumers benefit longer from high quality affordable textiles, fast fashion is out of fashion, and economically profitable re-use and repair services are widely available.”

Although such services are still only a niche market, “they have been shown to extend the lifetime of textile products, and are a cost effective and affordable alternative to fast fashion,” the commission says. “As fast fashion is linked to the growing use of fossil-fuel based synthetic fibres, shifting to more sustainable business models will reduce both the dependency of clothing producers on fossil fuels and their impacts

on climate change and microplastic pollution.”

Sarah Moore, a partner in London-based law firm Hausfeld, wonders whether the measures set out in the strategy will ever make it onto the statute books across the EU. “If they do, such legislation would likely impact upon the viability of fast fashion companies operating across the EU, many of which have bloomed throughout the pandemic,” she wrote in May.

“We may also see a new trend in related litigation, with regulators, consumers and potentially competitors policing the compliance of textile manufacturers and retailers with regulation inspired by the EU Strategy – making slow, sustainable and responsibly produced textiles the norm across the fashion world.”

With the EU strategy for 2030 now in place, the fashion world is under growing pressure to change. “The way we produce and consume clothes is highly, highly unsustainable,” European Commission Vice President Frans Timmermans told the Global Fashion Summit in Copenhagen in June. “In the European Union alone, we waste about 5.8 million tonnes of textiles every year. That is nearly 11 kilos per person. And across the world, a truckload of textiles is landfilled or incinerated, every second.

“The wasteful relationship we have developed with textiles pollutes our world. It uses excessive amounts of water and energy, harms nature, and drives greenhouse gas emissions across the globe. Fast fashion is particularly problematic, and the need for change is undeniable,” Timmermans said. “Let’s relegate fast fashion to its correct place in history: the past.”

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Greening garments

A Taiwanese-founded company operating from Singapore and Shanghai seeks to slash the textile industry's voracious appetite for energy and water. With a presence in three of the four Lower Mekong countries, the privately owned company has just raised USD 100 million to fund expansion to meet booming demand for its new technology.

Among companies trying to address the textile industry's carbon footprint is Newtech Textile Singapore Pte Ltd. (NTX), a private company based in Singapore and Shanghai that's developed a waterless colouration technology now being applied at joint ventures in Cambodia, Thailand and Viet Nam as well as China and Indonesia. On 1 August this year, Chinese private equity firm Centurium Capital Management Ltd announced it had completed a new round of financing for NTX, raising almost USD 200 million for operational needs to meet rapidly growing demand. Centurium said the funding was secured after NTX became a preferred supplier to international clothing brands such as Adidas, the German sportswear giant.

'The waterless dyeing and printing technology is estimated to reduce water use by 90 percent, energy consumption by 65 percent and dye use by 40 percent'

Garry Liu, managing director at Centurium, said NTX was "solving the long-standing pain points of traditional textile manufacturing of high water and energy consumption and pollution." The waterless dyeing and printing technology is estimated to reduce water use by 90 percent, energy consumption by 65 percent and dye use by 40 percent. "The company has established a Southeast Asia-based ecosystem of textile processing plants to become the next generation sustainable eco-friendly supply chain partner for some of the world's biggest fashion and apparel brands," Liu said.

In a joint statement, Centurium and NTX said the new funding was timely given recent initiatives such as the EU strategy for textiles adopted this year (see page 21) and the Fashion Industry Charter for Climate Action – signed by companies such as Adidas, Nike and Gap – to reduce greenhouse emissions by 2030. The statement also noted the Vietnam Textile and Apparel Industry Association's goal to reduce water consumption

by 20 percent and energy consumption by 15 percent by 2030.

The statement pointed to studies by the European Parliament and the International Labour Organization showing the textile industry accounting for 10 percent of global greenhouse emissions of which more than a third are generated by dyeing, printing and finishing. The dyeing and printing prices is "ripe for technological disruption due to its technical shortcomings and environmental impact," it said.

'Urgency of climate change'

In a separate statement, NTX said: "The scale of the nearly USD 200 million investment is indicative that the financial community has recognized the urgency of climate change and the potential returns associated with impactful and ready-to-implement innovations for the apparel and clothing industries. The funds will be used to accelerate our growth, double down on innovative sustainable solutions, and bring transformational change to the textile industry."

NTX co-founders Calvin Chong and Sandra Chou developed the waterless technology after moving from Taiwan to China where they settled in Shanghai in the late 1990s. It was there that they found a "critical mass of both the talent, the workshops, the chemical engineering expertise" to seek a fundamental change to the chemistry and other processes for printing on fabrics, said Jeffrey Hsu, the company's chief technology and marketing officer in Singapore.

Speaking to the World Textile Information Network in May this year, Hsu said the plan was to adopt techniques used in the paper printing industry. "With paper



Mr Chang and Ms Chu

PHOTOS: NTX



Mr Hsu

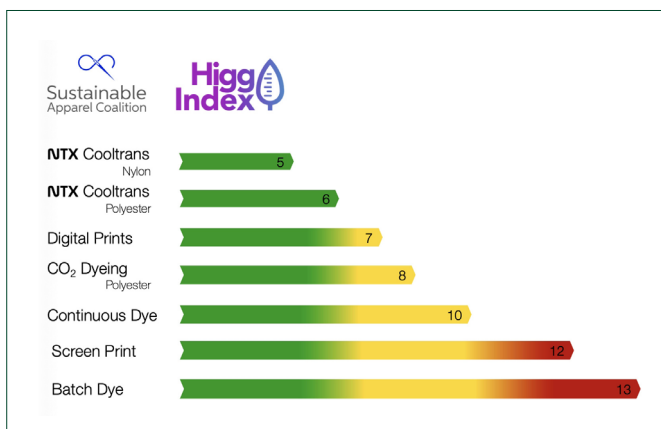
PHOTO: NTX

it's quite simple, relatively, to do that since there's only four primary different types of paper in the world," he said. But the textile industry uses various types natural and synthetic fibers including woven, non-woven and knitted fabrics. "Rather than looking to recreate the wheel, so to speak, with different novel approaches to dye, they looked at how to create a novel ink chemistry."

Research took seven years, and commercialisation another seven. Hsu said the NTX technology was a hybrid of various processes used in the textile industry, notably digital printing and sublimation – the process of transferring a substance from solid state to gas without becoming a liquid. "It's a little bit of everything, all the benefits of, taking out all the nasty bits," he said.

'Cool transfers'

Peter Decorte, chief operations officer in Singapore, said the company's proprietary process known as "NTX Cooltrans" took its name from the cooler temperature required to transfer ink onto the fabric at around 80°C. Such "cool transfers" compare with around 130°C in a traditional dye bath. In the process of washing off residual dyes "water use is very low," Decorte said "The BOD and COD values of what is washed off are very, very acceptable," he added, referring to biological oxygen demand and chemical oxygen demand – key measures of water pollution.



Index showing low impact of NGX colouration system

SOURCE: NGX



Mr Decorte

PHOTO: NTX

Hsu said the company realised it was on to something when it subjected Cooltrans to an environmental assessment by the Sustainable Apparel Coalition, which has more than 250 members in the clothing, footwear and textile sectors. Based in San Francisco, the coalition has developed a measure known as the Higg Materials Sustainability Index (MSI), one of five tools that standardises value-chain sustainability for all industry participants.

NTX expected to "probably be better than any of the conventional technologies, if not comparable to some of the newer technologies," Hsu said. Compared to processes like batch dyeing, screen printing and continuous dyeing, the MSI indeed showed that Cooltrans had a much lower environmental impact. But the NTX process was also found to be more sustainable than digital printing, with better scores for both polyester and nylon (see chart below).

"We were taken aback," Hsu said. "That was the starting point to really get our foot in the door, to talk to the brand houses, to talk to people in the industry." To be sure, the methodology of the Sustainability Apparel Coalition has been questioned. Hsu acknowledges that the Higg MSI is "not perfect. There's still a lot of ins and outs of the Higg index that are to be desired – sure. But it is still, at face, the simplest way to make an apples-to-apples comparison."

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Australia announces **three-year initiative** to promote **fishways** in Lower Mekong

Demonstration sites planned for Phnom Penh, Vientiane and Siem Reap, where a regional forum is scheduled to be held in 2023 to showcase the benefits of fishways for food security

Australia has announced a AUD 5 million (USD 4 million) initiative to promote fishways in the Lower Mekong Basin. Most activities under the three-year “FishTech” initiative will be implemented in Cambodia and Lao PDR, with fish biologists and irrigation engineers from Thailand and Viet Nam taking part in training activities.

Speaking at the Stung Chinit fishway in Cambodia’s Kampong Thom Province on September 2, Australian Ambassador Pablo Kang said: “Managing and protecting water and related resources is becoming increasingly critical in this region, with its fast-paced economic development, population growth, and changing climate.”

The initiative is being carried out by the Australian

MRC publications on fish-friendly schemes

The launch of the three-year project follows the MRC Secretariat’s publication of two sets of guidelines and a monitoring manual for fish-friendly irrigation schemes. These documents – *Guidelines to Prioritizing Fish Passage Barriers in the Lower Mekong Basin*, *Guidelines on Fishway Design, Construction, Operation, Maintenance and Adjustment* and *Fish Passage Monitoring Manual* – were all published in December, 2011.

Centre for International Agriculture Research (ACIAR) in partnership with the Fisheries Administration of the Cambodian Ministry of Agriculture, Forestry and Fisheries, the Cambodian Ministry of Water Resources and Meteorology as well as the National University of Laos and the Lao Ministry of Agriculture and Forestry.

Speaking at the launch ceremony at Stung Chinit, a major tributary of the Tonle Sap Lake, ACIAR Chief



Tim Marsden from Australasian Fish Passage Services Pty Ltd (left) speaking with Australian Ambassador Pablo Kang (second from left), ACIAR Chief Executive Andrew Campbell (second from right) and Cambodian Ministry of Agriculture, Forestry and Fisheries Undersecretary of State Khun Savoeun (right) at Stung Chinit Fishway on September 2

PHOTO: LEM SAMEAN

Two new USAID-funded fishways completed in northwest Cambodia

The United States Agency for International Development (USAID) announced on August 30 the completion of two new fishways in Pursat province in northwest Cambodia. In a statement, USAID said the fishways would connect fish with critical upstream habitats. “These fishways also demonstrate that small-scale fish passes are a feasible, relatively inexpensive solution to the problem of declining fish stocks,” it said.

Cambodia’s Fisheries Administration partnered with USAID to build two other fishways in 2019 and 2021. “Monitoring of those sites demonstrated that over a million fish representing more than 100 species use the fishways to access over 2,000 kilometers of previously unreachable habitat,” the statement said.

The new fishways are part of a five-year initiative supported by USAID and the US Department of the Interior in partnership with the Fisheries Administration and ACIAR. Other partners are the Mekong River Commission (MRC), the Southeast Asian Fisheries Development Center (SEAFDEC) and Japan’s Ministry of Agriculture, Forestry, and Fisheries. The initiative – part of the USAID Smart Infrastructure for the Mekong (SIM) program – has helped Lower Mekong countries in the inventory and prioritization of barriers to fish passage, training on fish passage design and engineering, and coordination between irrigation and fisheries departments.

“Locally-caught fish serve as a key source of food for many Cambodians,” said Rebecca Black, the Acting Mission Di-

rector for USAID in Cambodia. “By protecting fish populations and their habitats, we hope these fishways will also contribute to improved health for the communities that depend on them.”

Further reading

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The newly completed fishway on the Svay Don Kau River in September (above) and location of existing and future USAID-funded fishways on tributaries of the Tonle Sap Lake in northwest Cambodia (below)

PHOTOS: LEM SAMEAN



Executive Andrew Campbell noted that fish provided two-thirds of the protein consumed by humans in the Mekong Basin. “Typically, Mekong fish species migrate upstream to breed and come back down again to

complete their life cycles,” he said.

“Structures like irrigation weirs or hydroelectric dams block fish migration upstream or downstream, ulti-

Fishways seen contributing to ADB strategy for 2030

The Asian Development Bank (ADB) reckons fishways can contribute to its strategy for 2030 in five priority areas. It also notes that fishways can not only be economically viable but also generate rapid returns in some cases – as shown by the Lower Mekong Fishway Support Tool (LMFST) developed by Australian researchers in 2019.

“Despite the important role that inland fisheries play in the human diet and rural income generation, ensuring fish movement in the design of irrigation infrastructure projects is often overlooked,” the ADB said in a report on Lao fishways published in 2020. “With growing investments in irrigation infrastructure and modernization, it is critical to reconcile irrigation and fisheries agendas.”

Continued fish productivity is seen as “essential” for reaching food security, poverty reduction and climate resiliency goals under the 2030 strategy.

“ADB should, therefore, ensure that its infrastructure projects pose no threat to the already diminishing fish population and, ultimately, to food security,” the report said.

“Ideally, in new ADB infrastructure projects, effective fishway construction should be required, and retrofitting of existing structures to incorporate fishways should be explored.” The five areas where fishways can contribute to the strategy are outlined below:

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ADB Operational Priorities	Contribution of Fishways
Addressing remaining poverty and reducing inequalities	Fish are an essential dietary component and represent a livelihood opportunity. For impoverished people, the catching of wild fish or the raising of fish represents both survival and commercial options. Fishways are necessary for the preservation and maintenance of wild fish and other aquatic life.
Accelerating progress in gender equality	Healthy wild fish stocks made possible by fishways are easily caught and sold, and prepared as household food, leaving more free time for girls and women (who are often responsible for household food preparation) for other more productive activities.
Tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability	Under climate change, many food sources, including fish, will come under extreme stress. Irrigation programs can increase land-based food supplies, while the inclusion of fishways as appropriate can enhance the survival of aquatic supplies.
Promoting rural development and food security	Fishways are the very definition of climate-smart practices and improved natural resource standards. They are essential for food security and nutrition. They are also potentially economically viable and have rapid payback in some circumstances, as evidenced by the application of the LMFST.
Strengthening governance and institutional capacity	Healthy wild aquatic life due to the inclusion of fishways in irrigation schemes will enhance sustainable growth. Exposing decision-makers to a range of analytical tools that draw from multiple disciplines leaves long-run benefits

mately threatening the food security of the region ... Well-designed fish passages mitigate the impact of irrigation development on fish migration, with lasting economic and social benefits for river-dependent communities."

As part of the initiative, Australia will fund the construction of fish passes at several locations including demonstration sites near Phnom Penh and Siem Reap as well as Vientiane. Australia's Charles Sturt University will meanwhile work with Cambodian fisheries scientists and irrigation engineers to develop a series of "masterclasses" to help build capacity for technical design and policy making.

ACIAR and the university will also work with the Fisheries Administration to host a regional forum in Siem Reap next year, where the benefits of the work in Cambodia and Lao PDR can be showcased to agencies and donors across the Mekong region.

"The launch of the FishTech initiative is the culmination of a decade of technical work to demonstrate the concept that it is possible to have productive fish and rice systems," said Lee Baumgartner, Acting Director of Charles Sturt University's Gulbali Institute for Agriculture, Water and Environment.

"Over the next three years, we will be developing masterclasses, demonstration sites and working with government and development agencies to improve policy and governance frameworks. The hope is that we establish a community of practice which ensures fisheries and irrigation sustainability into the future."

Staff at the Gulbali Institute have been working on fishway development with local partners in Lao PDR since 2008 and Cambodia since 2018. The institute has also been developing fishways in Myanmar and – in partnership with United States Agency for International Development (USAID) – Thailand and Viet Nam.

'Accelerated development'

"The assistance of our Australian and US partners has greatly accelerated development of fish passage in Cambodia, which is providing direct benefits to the local communities in catchments where fish passage has been established," said Tob Chann Aun, deputy director of the Cambodian Fisheries Administration's Inland Fisheries Research and Development Institute (IFReDI). "Our future programme will expand on this very successful work and spread fish passes to many areas in Cambodia."

Pioneered in Europe and North America for migrating cold-water fishes like salmon, fishways have since been developed to help aquatic species migrate in tropical rivers, notably in South America, Australia and – most recently – the Lower Mekong Basin.

A key partner for Charles Sturt University's work in Cambodia and Lao PDR has been Australasian Fish Passage Services Pty Ltd, a company that has installed 25 "cone" fishways in Australia and Southeast Asia. Such fishways – known as "dragon teeth" fishways in the Lao language – use concrete cones placed below a barrier to create pools like a rocky stream bed. These allow water to flow downstream and fish to swim upstream from pool to pool – and eventually past the barrier.

"It's been great to see Australian-developed fish passage technology implemented so successfully in the Mekong region, with hundreds of thousands of fish passing barriers where they previously could not," said Tim Marsden, a fish biologist who serves as the company's principal.

"This has directly benefitted the local communities in these areas and we look forward to learning from these structures and assisting local organisations to construct more fishways suitable for local fish species," he said. The launch of the Australian initiative on September 2 took place at a fishway built with assistance from the Asian Development Bank. Completed in 2006, the fishway is based on a design for the Ben Anderson Barrage on the Burnett River in the Australian state of Queensland (see *Catch and Culture*, Vol 6, No 3).

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Confronting the growing odds of a late and disorderly energy transition

It's not too late, argues a team of central bankers led by Bank for International Settlements Deputy General Manager Luiz Awazu Pereira da Silva. On the contrary, the world energy crisis of 2022 – the most acute in half a century – presents a narrow but unique opportunity to accelerate the transition to net zero. The Central Bankers and Supervisors Network for Greening the Financial System (NGFS) published the team's assessment on September 7, 2022, a day after releasing Phase III of its climate scenarios. A summary of the assessment appears below.

The release of Phase III of the NGFS climate scenarios on September 6 (see pages 30 and 31) coincided with very particular circumstances for the global economy with three main developments.

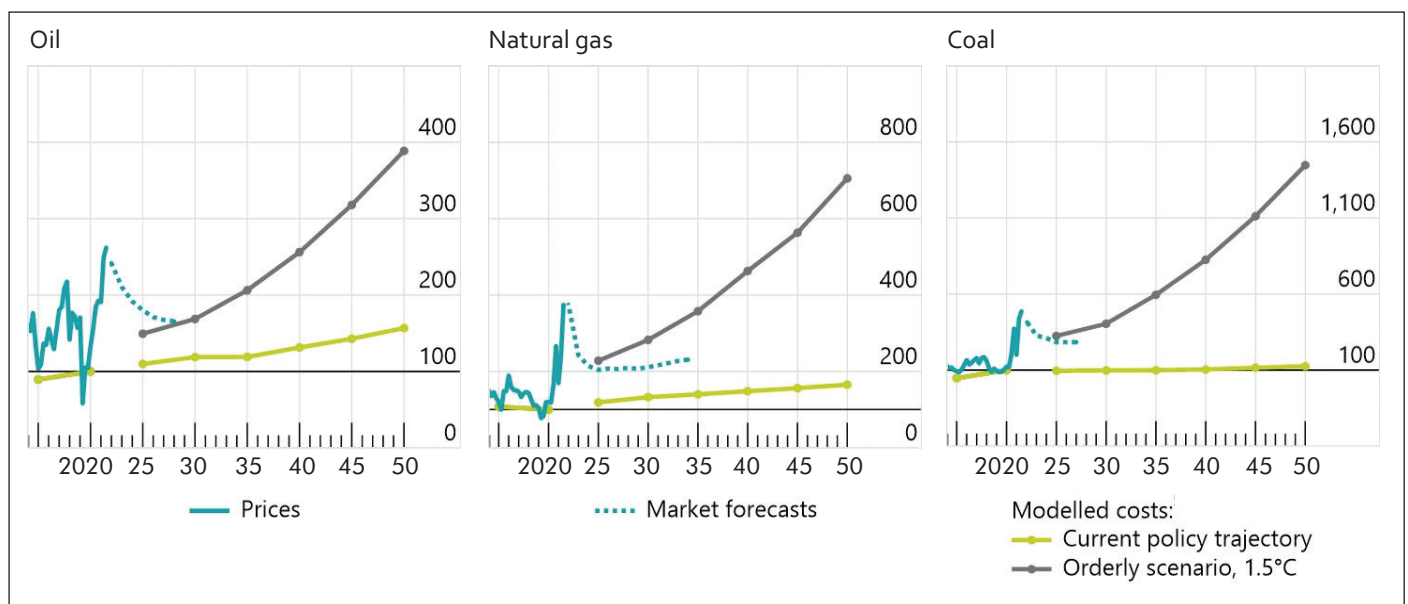
First, the Russian invasion of Ukraine in early 2022 exacerbated increases in fossil fuel prices, which started in 2021. Compared with December 2020, prices had

increased by 2.5 times for oil and 4 times for natural gas as of mid-2022 (see chart below, left and centre panels). Attempts to find quick substitutes to ease the gas shortage spurred dramatic demand for coal (right panel). Prices have been high and volatile ever since.

Second, inflation has picked up, notably on the back of higher oil and gas prices with a possible contribution from the energy transition. Central banks have been addressing this with determination in a timely fashion by tightening monetary policy. But increasing the supply of clean energy is more necessary than ever.

Third, the global economy has been confronted by an unprecedented number of climate-related extreme weather events – from floods in Europe and China a year ago and now Pakistan to repeated extreme heat-waves and droughts in South Asia, Europe and elsewhere over the past six months, not to mention a series of wildfires. These events strongly illustrate worse developments to come as climate change becomes more visible and chronic consequences accelerate.

Fossil fuel price developments and transition scenarios



Realised prices based on Brent crude futures, CME natural gas physical futures and Rotterdam coal futures. The modelled costs show the sum of primary energy price and carbon tax projections based on average emission intensities. The scenarios are neither a forecast of what is likely to happen nor a description of what should happen, but an illustration of what could happen. This includes some adverse scenarios that explore the impact of a delayed or a disorderly transition towards net zero. The global spike in energy prices is both more adverse and more immediate than any of the designed scenarios which are based on forecasts.

SOURCE: NGFS (2022F)

What is the NGFS?

The Central Banks and Supervisors Network for Greening the Financial System (NGFS) first met in Paris in early 2017. The founding central banks and financial supervisors were from eight countries – China, France, Germany, Mexico, the Netherlands, Singapore, Sweden and the United Kingdom. As of June this year, the network – whose secretariat is hosted by the Banque de France – had 116 members and 19 observers, accounting for more than 85 percent of global greenhouse gas emissions.

Six ASEAN central banks are NGFS members – the National Bank of Cambodia, Bank Indonesia, Bank Negara Malaysia, Bangko Sentral ng Pilipinas, the Monetary Authority of Singapore and the Bank of Thailand. Among other regional central banks, the Reserve Bank of Australia, the People's Bank of China, Bank of Japan, Bank of Korea and the Reserve Bank of New Zealand are also members.

Observers include the Bank for International Settlements (BIS) in Basel, Switzerland. Established in 1930, the BIS is the world's oldest international financial institution – predating the International Monetary Fund (IMF) and the World Bank by 14 years.

The central banks that founded the BIS were from Belgium, France, Germany, Italy, Japan, Switzerland and the United Kingdom. The BIS is now owned by 63 central banks representing 95 percent of world GDP.



First unofficial meeting of the BIS board of directors in Basel in 1930. The BIS played a key role in settling reparation payments imposed on Germany after World War I (1914-1918).

SOURCES: NGFS AND BIS

The NGFS Phase III scenarios provide a first attempt to measure the impact of the growing frequency and intensity of acute physical risks on GDP while improving estimates of the impact of chronic physical risks. Despite being conservative and partial, these estimates under the *Current Policies* scenario are strongly diverging from those under an orderly transition *Net Zero 2050* scenario as early as 2030, rising to a 5 percentage point difference in 2050 and increasing dramatically afterwards.

Shifting away from gas to coal, rising global coal consumption to all-time highs and expanding natural gas infrastructure are major immediate setbacks for the decarbonisation of the global economy. Moreover, the latest estimate shows that carbon emissions were on the rise again in 2021, further depleting the remaining carbon budget. The jury is still out on the longer-term effects of these relative price changes in the primary energy mix and whether they can spur the much-needed reduction in greenhouse gas (GHG) emissions.

However, the NGFS scenarios can shed light on the impact of these developments on the transition and help navigate the current difficult choices.

Growing odds of a late and disorderly transition

The conflict in Ukraine, in addition to being a tragedy, is a wakeup call to the costs and risks of fossil fuel dependence. It has offered a unique opportunity to accelerate the transition to low-carbon energies. The higher cost of producing energy with fossil fuels has three effects. First, it spurs energy efficiency – necessary to reach net zero emissions by 2050, as evidenced by the massive adjustment following the 1970s oil price shocks. Second, it makes renewable and nuclear energies much more economically attractive. At a time when part of the world has already been investing in the energy transition, the relative returns on such investments are much higher than they were a year ago. Third, it may also spur investment to increase fossil fuel production, although returns could be compromised by the future tightening of climate policies (via regulation or carbon pricing mechanisms).

The transition requires major investments in renewable electricity infrastructure and storage – 40 percent more each year on average in the *Net Zero 2050* scenario compared with the *Current Policies* scenario. But it also requires fossil fuel investment decreases of 40 percent in extraction and 70 percent in electricity generation

Continued on page 32 ...



Third vintage of climate scenarios for central banks and financial supervisors

The scenarios updated by the Central Bankers and Supervisors Network for the Greening the Financial System (NGFS) are a framework to assess and manage risks by exploring the transition and physical impacts of climate change. They show that reaching net zero CO₂ emissions worldwide by 2050 – to limit global warming to 1.5°C above pre-industrial levels – will require an ambitious transition across all sectors of the economy. Significant investment would need to flow towards clean energy so renewables and biomass deliver 70 percent of primary energy needs by 2050. The scenarios show that the macroeconomic impact of doing nothing to mitigate climate change would be extremely harmful, especially in the medium-to-long term as global GDP could decrease of about 20 percent at least by 2100.

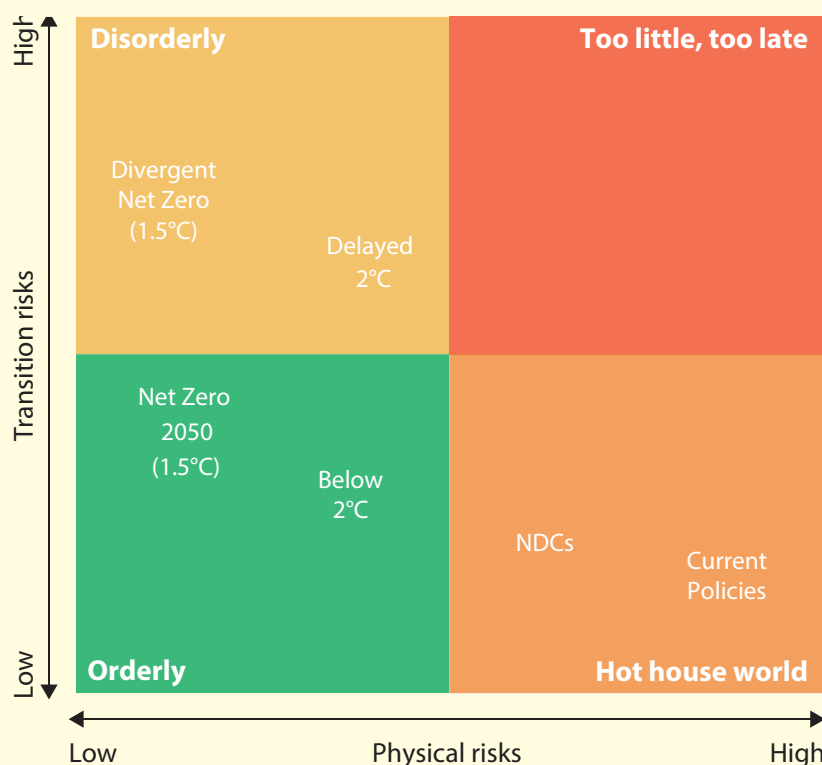
“The latest iteration of the NGFS scenarios could not have been more timely,” said NGFS chairman Ravi Menon, Managing Director of the Monetary Authority of Singapore, one of the network’s founding members in 2017. “Recent events have underscored that both climate change and energy transition are already happening. The droughts in Europe and China and the floods in Pakistan and India are tangible demonstrations of the devastating effects of climate change. The spike in fossil energy prices arising from the war in Ukraine is an early indication of what a disorderly energy transition might look like.”

Mr Menon noted that the latest NGFS scenarios released on September 6 included projections of the potential losses from extreme weather events like floods to complement the specific impacts of chronic climate changes on the macroeconomy in the previous iteration. “They also shed light on the potential disruptive impact of the current sharp rise in global energy prices, and the importance of securing an orderly energy transition to net zero,” he said. “The NGFS will continue to fine-tune the climate scenarios to allow for more comprehensive and relevant applications, support more comparable climate related disclosures, and enable climate-

resilient business and risk decisions.

Six scenarios

Each of the six NGFS scenarios explores how climate policy, emissions and temperatures evolve (see below). In the two scenarios for orderly transitions to carbon neutrality, *Net Zero 2050* limits global warming to 1.5°C through stringent climate policies and innovation, reaching global net zero emissions around 2050, while *Below 2°* gradually increases the stringency of climate policies with a two-thirds chance of limiting global warming to below 2°C. Under the two scenarios for disorderly transitions, *Divergent Net Zero* reaches net zero around 2050 but with higher costs due to different policies in sectors leading to a quicker phase-out of oil whereas *Delayed Transition* assumes annual emissions don’t fall until 2030. Strong policies are needed to limit warming to below 2°C. Negative emissions are limited. Under the two worst-case scenarios *Nationally Determined Contributions (NDCs)* includes all pledged targets even if not yet backed up by implemented effective policies while *Current Policies* assumes that only implemented policies are preserved, leading to high physical risks.



SOURCE: NGFS (2022b) AND CHHUT CHHEANA

Transition and physical risks

Climate risks are either transitional or physical. Transition risks – such as policy and regulation, technology development and consumer preferences – affect business profitability and household wealth, creating financial risks for lenders and investors. They also affect the broader economy through investment, productivity and relative price channels, especially if the transition leads to stranded assets. Physical risks are either chronic or acute. Chronic risks – especially from increased temperatures, sea levels and precipitation – may affect labour, capital, land and natural capital in specific areas such as agriculture. These changes will require significant investment and adaptation from companies, households and governments. Acute risks are from extreme weather – heatwaves, typhoons, floods, drought and wildfires, for example – and can disrupt businesses and damage property. With increased warming, they could also lead to persistent longer term impacts on the economy. These events can increase underwriting risks for insurers, possibly leading to lower insurance coverage in some regions, and impair asset values.

The scenarios of the NGFS, the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) provide transition pathways with different – but consistent – results. As they were developed to assess risk, the NGFS scenarios don't always have IPCC or IEA equivalents as the latter focus on transition pathways. But the *Net Zero 2050* scenarios are well aligned in several areas, notably gas and final energy use, wind and solar share in electricity, and carbon dioxide removal.

So what's new?

The latest scenarios have new economic and climate data, policy commitments and model versions. Country-level commitments to reach net zero emissions are as of March this year so include those made at the UN Climate Change Conference in Glasgow in November, 2021. The new scenarios also include updated GDP and population data from the IMF's World Economic Outlook in October, 2021 and the latest trends in renewable technologies such as wind and solar.

They also have better modeling of physical risks. "Estimates of GDP losses from chronic risks now more fully account for model uncertainty," the NGFS says. Under the *Current Policies* scenario, such losses would rise from more than 6 percent in 2050

to as much as 18 percent by 2100. Moreover, the macroeconomic impact of acute risks has been included for the first time and the new scenarios have increased breakdowns for the transport and industry sectors.

Selected results

The latest scenarios differ markedly in their economic impact, with significant uncertainty in the size of estimates and variation across region (losses are much higher in tropical and semi-tropical regions). GDP losses from physical risks vary in line with different temperatures projected. Impacts are similar in the first half of the century but then start strongly diverging. By 2100, impacts are by far highest in the *Current Policies* scenario (up to 20 percent of GDP) as temperature targets and the corresponding decarbonisation are missed. For all scenarios and time scales, physical risks outweigh transition risks. Stringent mitigation in line with the *Net Zero 2050* scenario will already be beneficial by 2050 and strongly reduces risks towards the end of the century.

To achieve net zero, significant investment would need to flow into green energy in the coming decades. Under the *Net Zero 2050* scenario, renewables and biomass would deliver 70 percent of primary energy needs worldwide. This is in marked contrast to the *Current Policies* scenario, where fossil fuels continue to dominate, even after accounting for current technology trends.

What's next?

The NGFS aims to improve the design of the scenarios and promote wide use by a broad range of stakeholders including private institutions and academics. More sectoral details and geographic coverage are envisaged especially for emerging economies. The NGFS also wants to manage tradeoffs between usability and complexity, while introducing short-term scenarios and better representing acute physical risk.

Cornelia Holthausen, a Director General at the European Central Bank, described the latest scenarios as "a unique tool to help us improve our understanding of climate-related risks and their impact on global economies over the years ahead. With their third vintage they clearly show the urgent need to invest more heavily in both climate adaptation and mitigation."



... continued from page 29

(based on the same two scenarios). Eventually, the success of a transition hinges on this capital reallocation, where overall annual increases in energy investment are limited to about 5 percent.

This capital reallocation is now even more challenging. Supply bottlenecks or technological advances were already critical issues constraining the pace of the transition. Now, new investments to increase the supply and diversify the sources of fossil fuel raise the probability of a *Too Little, Too Late* scenario. It also puts international collaboration at risk and raises the odds of a disorderly transition.

The odds of a *Too Little, Too Late* scenario are growing. But a successful net zero transition is still in reach. The cost-benefit analysis of such an option is far more favourable due to the importance of energy security.

The more certainty investors have about government commitments to achieve the temperature objectives of the Paris Agreement – and their willingness and capacity to maintain fossil fuel prices at a relatively high level even after the war (via higher carbon pricing or incentives for low-carbon energy for example) – the larger the funding of greener production and consumption.

The global energy crisis is an opportunity to tighten regulations in the real economy (by phasing out fossil-fuel vehicles, for example), accelerate the implementation of carbon-pricing systems and provide subsidies for renewable and other transition technologies to at least compensate for the normalisation of fossil fuel prices forecast in the near term. This means giving up the future possibility of cheaper fossil-fuel energies which means partly missing out on their disinflationary impact, if not compensated by lower renewable energy, to make sure time is wisely spent on adjustments to avoid fossil fuels. The consensus among experts is that an early and orderly transition is less costly than a late and disorderly adjustment. If fossil fuel prices are simply maintained at current levels, there is no further inflationary impact. Turning to price stability, central banks are well placed to secure the return of inflation to low and stable levels even without a windfall of future decreases in fossil fuel prices.

Shift in fossil fuel prices in a long-term perspective

Since the start of the war, fossil fuel prices have quickly caught up with future prices needed to achieve the NGFS orderly scenario for *Net Zero 2050*. For instance,

the oil price increase between 2020 and mid-2022 is as large as the increase required by 2040 under this scenario. If sustained, this increase should discourage recourse to oil and other fossil fuels by nearly as much as a carbon tax increase would generate by 2040. But there are several caveats.

Short-term costs are associated with abrupt shifts in fossil fuel prices. When a 10 to 15-year price trajectory is known in advance – as in orderly scenario for *Net Zero 2050* – the adjustment costs of the transition can be spread over time. But a sudden price increase as in 2021-22 is much harder. Businesses and consumers cannot adjust production and consumption overnight or within a few months. So even an abrupt and immediate transition to net zero, would be more costly than under the orderly NGFS scenarios.

But this is by far the cheapest and safest possible option. Supply constraints on natural gas and changes in relative prices could also lead to an opposite course of action – replacing gas with coal which, based on preliminary studies, could more than double GHG emissions. A potential risk here is to see substitution in energy consumption translated into production of more fossil fuel energy. This could make the low-carbon transition much less likely, leading to the worst-case *Too Little, Too Late* scenario with extremely high costs driven by fossil fuel energy prices in the short-run and a dramatic increase of acute and chronic physical risks in the long-run. Some European countries have started to think about a return to coal and emerging markets like China and India have raised coal production following winter power shortages in late 2021.

The situation is aggravated by too fast energy price increases in the short term which have impaired people's disposable income and weakened their purchasing power. Low-income households are suffering the most. Targeted government support like temporary subsidies could help people in need live through this accelerated transition by changing their consumption behaviour in the longer term. Targeted government investment in infrastructure needed to transition – such as railways and low-carbon cities – and research into new technologies would also increase the chance of an orderly transition.

In the medium to long run, consumption of fossil fuels is most likely to fall if prices remain high and renewable energy consumption increases. The years following the oil shocks of the 1970s witnessed major improvements and innovations that led to energy efficiency and

a more balanced energy mix. We especially saw increased use of nuclear energy in response to oil price surges.

Maximising the odds of an orderly transition

The energy crisis has put us on a path towards a delayed and disorderly transition. The risk of shifting to a *Too Little, Too Late* scenario, too abrupt changes in energy prices and constraints to increase low-carbon generation capacity in the short term have heightened risks of a return to the use of coal to ensure energy security. This can strongly delay promised carbon emission reductions, or even put the transition at risk.

What can we do to alter the transition course back and ensure we reach the Paris Agreement goals while minimising the related economic and social costs?

First, governments need to reaffirm collective and indi-

'We must seize the opportunity presented by the current high prices'

"Climate change is not taking a pause for the current energy crisis," said Monetary Authority of Singapore Managing Director Ravi Menon, who currently chairs the NGFS. In a statement released on September 7, the Singapore central bank governor noted that natural disasters were increasing in frequency and intensity.



NGFS Chairman Ravi Menon

PHOTO: MONETARY AUTHORITY OF SINGAPORE

"In dealing with the energy crisis, the key risk to guard against is to lock into a carbon-intensive pathway that will prove very costly to transition away from in future or lead us into catastrophic climate change," he said.

"We must ensure that any increase in carbon intensity to alleviate the energy crisis is strictly temporary. We must seize the opportunity presented by the current high prices of fossil energy to accelerate investments in renewable energy and substantially increase energy efficiency. The financial sector must stand behind this effort."

vidual commitments to tackling climate change. They also need to make their transition plans transparent and adapt them to the latest geopolitical developments. Hopefully, this is already happening.

Where possible, governments could also think about ways of making carbon pricing a pivotal instrument for the energy transition. The near doubling of oil prices from an average USD 55 a barrel to USD 115 in May 2022 will likely reduce oil consumption in the long run. When the geopolitical situation eases, pressure on energy supply will be alleviated and fossil fuel prices will fall. Policy makers should therefore seize the opportunity to lock in higher fossil fuel prices for end users. An obvious way would be to scale up carbon taxes or other price regulations to discourage fossil fuel consumption. Governments could act now to design and implement carbon-pricing mechanisms, scale back energy-related tax cuts and subsidies or introduce carbon taxes or emissions trading systems. To help vulnerable households, governments should leave relative price signals to function to the extent reasonably possible – by providing monetary subsidies, for example. International solidarity and cooperation would greatly help the implementation of carbon taxes worldwide and minimise collateral damage to competitiveness and growth.

Finally, even with carbon pricing in place to keep fossil-based energy expensive, the transition away from fossil fuels to alternative energies and new technologies cannot happen without a major reallocation of capital to fund more efficient energy use, storage technologies and a higher share of renewables in the energy mix. In this regard, finance – both public and private – plays a critical role. And this calls for collective and timely actions to scale up green and transition finance and spur the much-needed innovation and technological progress without which a green transition is just not possible.

In this regard, the Central Banks and Supervisors Network for Greening the Financial System has leveraged its members' experience and set out some key considerations to enhance market transparency and develop market incentives to unlock new efficient tools for financing the transition. Although an abrupt transition to net zero is the most preferable option to ensure we reach our climate goals, the implied economic and social costs could disproportionately impact certain parts of populations. Targeted government measures are needed to limit inequalities and incentivise changes in consumer preferences.



Lessons learned from Southeast Asia and Africa in assessing acute physical risks

In publishing its latest climate scenarios, the NGFS released a technical document on practical lessons from emerging markets and developing economies (EMDEs) for drawing up scenarios with extreme weather events. Prepared by a team co-chaired by the World Bank and Banco de México, the document notes that these economies are among the “most vulnerable” to climate change and “significantly exposed” to both physical and transition risks. The document focuses on acute physical climate risks associated with extreme weather. Unlike chronic risks such as gradual increases in temperatures, acute risks are associated with increasingly frequent or severe weather like typhoons, storms, floods and droughts. “Physical climate risk assessment provides a structured approach to identify, analyze, and evaluate such risks,” the document says. “It can help improve the resilience of the financial sector and identify opportunities for climate adaptation finance.”

‘Unique challenges’

But for EMDEs, “performing a physical climate risk assessment poses unique challenges that can discourage authorities from engaging in such an exercise. In addition to the diverse climate risk profile and economic status of EMDEs, scarce and poor-quality data coupled with limited local technical capacity make it difficult for EMDEs to apply existing frameworks for climate risk assessments or build on experiences from advanced economies.”

The team looked at recent assessments in Southeast Asia (Indonesia and the Philippines), North Africa (Morocco and Tunisia) and the West African Monetary and Economic Union (Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo). “The main lesson from these recent experiences is that climate risk assessment methodologies used in developed countries may not be fully replicable in EMDEs,” the team concludes. Instead, the team proposes a practical six-step framework for assessing acute physical climate risks. Each step incorporates one of six preliminary lessons drawn from recent experience in Asia and Africa.

- Country approaches should be tailored to needs and objectives identified by local stakeholders.
- Caution should be used when interpreting outputs from global data sets that may not have

been validated at the country level.

- The scope and approach of the analysis should be based on country specificities, data availability, and local technical capacity.
- Scenarios should be plausible, explore a range of different options and capture key climate-related financial risks and the geographic distribution of hazards and exposures.
- Quantitative analysis should capture both indirect and direct impacts, as well as short and longer-term effects on the economy and sectors.
- Presentation of results should focus on the order of magnitude and trends, and discuss uncertainties, assumptions, and limitations. They may initially focus on key stakeholders in the financial sector, but results may also be relevant to a wider audience.

This final step may be especially relevant for EMDEs. “Understanding the full extent of direct and indirect impacts of climate risks, and how they permeate through the financial system, has a wide range of applications, not only for financial sector risk management but also for broader public financial management,” the document says. “For example, a large proportion of banks are owned by the state in many EMDEs. The state may thus be exposed to climate risks through contingent liabilities associated with the banking sector. These contingent liabilities come in addition to other climate risk-related contingent liabilities faced by the state, including physical damages to public assets and infrastructure.” Moreover, insurance penetration tends to be low in EMDEs so “households and businesses rely on governments for shock-responsive financial assistance.”

“Acute physical climate risk is a new topic,” the team concludes. “The complexity and cross-disciplinary nature of the assessment requires broad expertise. Highly specialized institutions and partners can be useful in designing a methodology, identifying key sources of information, and possibly supporting EMDEs through the risk assessment itself. This practical framework is a first attempt to adjust climate risk assessment to the needs and specificities of the EMDEs through a first set of country cases. It is meant to be further refined as more EMDEs perform climate risk assessment.”

Conclusion

The energy crisis puts the world economy at a crossroads. It may have significantly heightened the risk of a disorderly energy transition – or at least a significant delay thereof – and is putting the entire transition at risk, with immense environmental and economic costs. Without readily available green replacements, abrupt price increases and the resulting rapid shutdowns of carbon-intensive energy sources put energy security at risk and could cause a GDP contraction of 5 to 10 percent within five years. At the same time, renewed demand for coal in the absence of sufficient natural gas supply delays the planned reduction in carbon emissions. An abrupt and immediate replacement of

'It is not too late to avoid a delayed and disorderly transition'

"The current crisis, with all its tragic dimensions, represents also a unique opportunity to take decisive action toward the net zero transition," said Bank for International Settlements Deputy General Manager Luiz Awazu Pereira da Silva, who led the ad-hoc group which prepared the note. In a statement released by the NGFS on September 7, Mr Pereira da Silva said the longer-term benefits of the crisis were "even stronger especially after the relative price shift with the sharp rise in the cost of fossil fuel.



BIS Deputy General Manager
Luiz Awazu Pereira da Silva

PHOTO: BIS

"This can be additional incentives to be used to show it is not too late to avoid a delayed and disorderly transition. Today, accelerating the transition is even more so our best option to reduce the social and economic costs, the large financial risks that climate change is bringing us. Naturally, this has to be done with pragmatic decisions and coordinated planning to help overcome the challenges associated with the scaling up of necessary investments in non-fossil energy sources and mitigate the negative redistributive impacts of 'fossilflation'."

fossil fuels with renewable sources of energy is not as easy and cheap as a pre-war orderly transition scenario would have implied.

The increase in fossil fuel prices is an opportunity to accelerate the energy transition. It means that returns on renewable energy are significantly higher than they were when oil prices fluctuated near USD 60 a barrel. The experience of the 1970s reminds us that abrupt increases in oil prices led to massive increases in energy efficiency and substitution away from fossil fuels.

Against the latest energy market developments, a comparative reading of Phase III of the NGFS scenarios provides important insights into where we are on this transition pathway – and what we can do to reverse course and ensure we transition to net zero. The key resides in designing appropriate pricing mechanisms to discourage fossil fuel consumption and making low-carbon energy sources more competitive through research and investment into renewable technologies. Policies to protect the most vulnerable, well-designed communications about the need to internalise the social costs of carbon-intensive energy and certainty about the carbon-pricing path are essential.

Further reading

NGFS. 2022a. NGFS publishes the third vintage of climate scenarios for forward-looking climate risk assessments. 6 September, 2022. Paris: Central Banks and Supervisors Network for Greening the Financial System.

NGFS. 2022b. NGFS Scenarios for central banks and supervisors. September, 2022. Paris: Central Banks and Supervisors Network for Greening the Financial System.

NGFS. 2022c. Climate Scenarios Sensitivity Analysis to Macroeconomic Policy Assumptions. September, 2022. Paris: Central Banks and Supervisors Network for Greening the Financial System.

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NGFS. 2022e. NGFS publishes a paper exploring the effects of the current energy crisis and the links with the NGFS climate scenarios. 7 September, 2022. Paris: Central Banks and Supervisors Network for Greening the Financial System.

NGFS. 2022f. Not too late – Confronting the growing odds of a late and disorderly transition. September, 2022. Paris: Central Banks and Supervisors Network for Greening the Financial System.



'ASEAN desperately needs to diversify its energy mix'

New study sees 'significant investment' in solar power and chargers for electric vehicles as part of Southeast Asia's energy transition

ASEAN needs to invest USD 946 billion by 2030 to meet short-term energy transition goals aimed at achieving net zero carbon emissions by 2050, according to a joint study by the International Renewable Energy Agency (IRENA) in Abu Dhabi and the ASEAN Centre for Energy in Jakarta. "A substantial increase in investments is required to accelerate the energy transition in ASEAN," the study says. "Policy support for energy sectors and cooperation among the ASEAN countries are crucial to enable the reallocation of capital towards sustainable solutions and to ensure active participation from a wide range of investors."

In his foreword to the study, ASEAN Center for Energy Executive Director Nuki Agya Utama says ASEAN countries are still too reliant on fossil fuels. "Coal's share remains dominant in the power sector, as does oil in transportation, and ASEAN desperately needs to diversify its energy mix," he says. "On the contrary, the intermittency of renewable energy sources, particularly solar and wind, remains an obstacle owing to the strain on the power grid. The potential of bioenergy feedstocks is not yet fully assessed or utilised, with only a 7 percent share of the transport fuel mix by 2020. In short, ASEAN needs to improve regional cooperation to speed up the establishment of flexible and reliable power infrastructure and the higher adoption of energy-efficient technologies through end-user electrification."

In the shorter term up to 2030, the study expects significant investment in some crucial energy transition technologies like solar power and chargers for electric vehicles (EVs). Solar photovoltaic energy "will be key to the region's short-term energy transition," it says, estimating investment of around USD 150 billion on an additional 240 GW of installed capacity. "Investment related to the development of EVs will also play an important role in the overall energy transition effort in the region. Electric chargers are crucial, with the installation of nearly 4 million units necessary by 2030, requiring nearly USD 50 billion." Investments

in infrastructure are also seen as crucial, with around USD 105 billion required for international and domestic transmission, and another USD 69 billion needed for local distribution.











In the longer term up to 2050, average annual investment of USD 210 billion will be needed to achieve net zero emissions. The study estimates the figure to be more than twice the region's GDP in 2018 and about 60 percent of 2050 values. Spread out over multiple decades, however, the investment represents only 2–7 percent of regional GDP, depending on the year.

Investment in the building sector is expected to account for 10 percent of overall investment out to 2050, requiring USD 21 billion a year. This is mostly related to energy efficiency improvement measures – light-emitting diode (LED) lamps, more efficient appliances and the development of low-energy buildings. The transport sector is expected to see higher investment needs, including USD 14 billion annually for EV chargers alone. The construction of EV charging infrastructure takes up over half of total transport investment. Energy efficiency investment in the transport sector in ASEAN will require USD 13 billion annually until 2050 and investments in biofuel supply will need to average USD 7-8 billion a year. The industry sector will need to make average annual investments of USD 9 billion over the same period, focussed on energy efficiency, including best-available technologies, practices and processes, as well as circular economy and renewable-based generation technologies.

The power sector will require the largest investment, estimated at USD 2,900 billion by 2050. Most investment is expected to be solar PV, coal and hydropower. "Generally, capacity investments make up around two-thirds of power sector investment, with the remaining one-third going into grids, infrastructure, storage and other enabling technologies," the study says.

ASEAN released the study during a meeting of ASEAN Energy Ministers chaired by Cambodia on September 15. In his opening address to the virtual meeting, Prime Minister Hun Sen said ASEAN "must focus on transition, which is a key task in promoting sustainable and resilient

ASEAN short-term energy transition investment needs (2018 - 2030)

		PARAMETER			TOTAL INVESTMENT (BILLION USD)
SHORT-TERM INVESTMENT REQUIREMENT 1.5-S* (2018-2030)	POWER	 Solar PV	Installed capacity (GW)	241	156
		 Other renewable energy (non-hydro)	Installed capacity (GW)	56	90
		 Hydro	Installed capacity (GW)	73	56
	GRID AND FLEXIBILITY	 Transmission (international)	km (thousand)	35	13
		 Transmission (national)	km (thousand)	247	92
		 Distribution	km (thousand)	2739	69
		 Storage	GW	15	8
		 Biofuel supply	million litres	57475	66
	ELECTRIFICATION	 EV chargers	million units	3.7	47
		 EV car sales	million units	13	349

* global warming scenario of 1.5°C above pre-industrial levels

SOURCE: IRENA AND ACE (2022)

economic recovery." As chair of ASEAN in 2022, he said Cambodia was keen to "promote participation, strengthen cooperation and pay more attention to accelerating the energy transition towards realistic common prosperity."

The ASEAN Energy Ministers discussed mobilizing finance to accelerate the energy transition during a meeting with counterparts from Australia, China, Japan, South Korea, New Zealand, Russia and the United States on September 16, 2022. "There is no single pathway to achieve a low carbon economy, but rather there are diverse paths for each country," a joint ministerial statement said. The meeting stressed the need to "explore a variety of options and utilize all technolo-

gies and fuels to ensure a stable and secure supply of energy for achieving economic growth."

Further reading

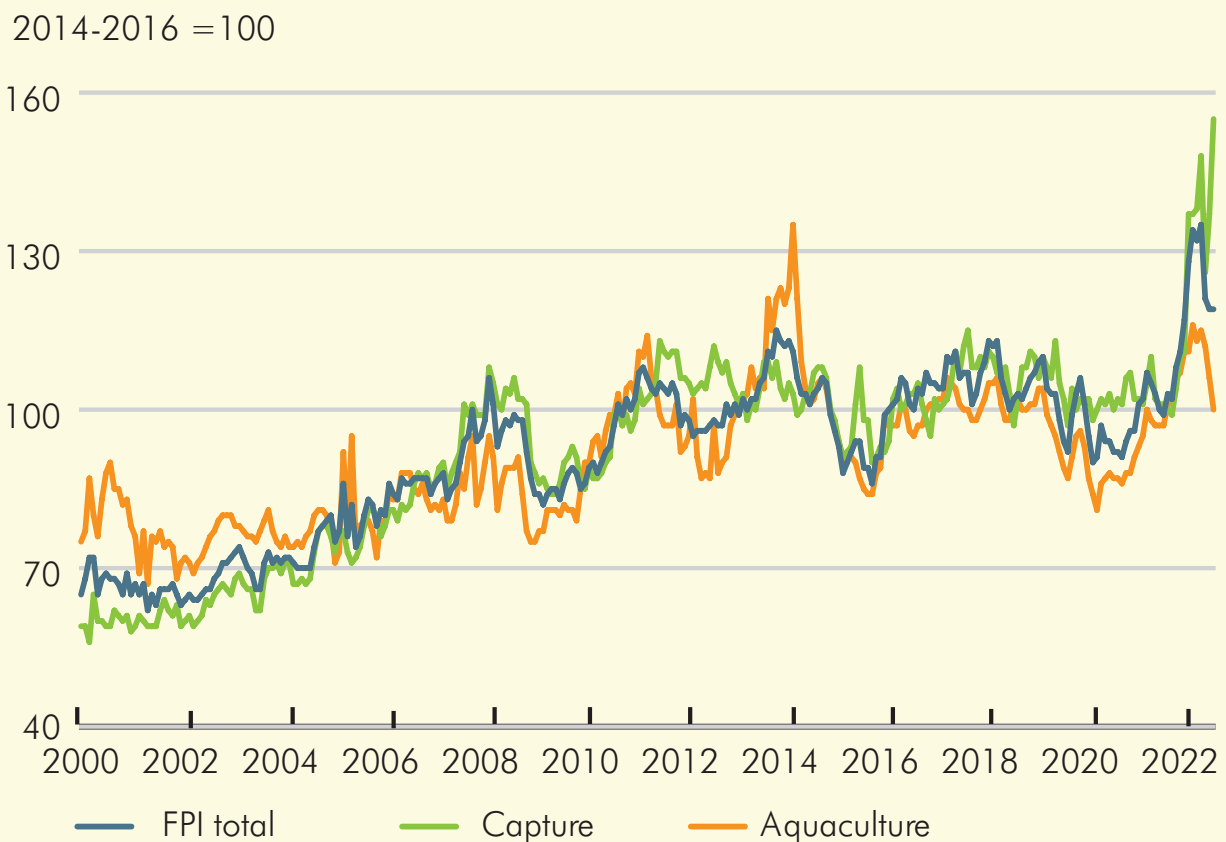
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FAO Fish Price Index



Source of the raw data for the FAO Fish Price Index: EUMOFA, INFOFISH, INFOPESCA, INFOYU, Statistics Norway.

Production, trade, utilisation and consumption FAO Food Outlook, November, 2022	2020	2021 Estimate	2022 Forecast	Change 2022/2021
	Million tonnes			%
Production	177.8	182.0	184.1	+1.2
Capture fisheries	90.3	92.3	92.1	- 0.2
Aquaculture	87.5	89.7	92.0	+2.6
Trade value (exports USD billion)	150.9	174.8	193.5	+10.7
Trade volume (live weight)	64.3	68.3	68.9	+ 0.8
Total utilisation	177.8	182.0	184.1	+1.2
Food	157.4	161.1	163.7	+1.6
Feed	16.4	16.9	16.4	- 2.8
Other uses	4.0	4.0	4.0	+ 1.1
Consumption per person				
Food fish (kg/year)	20.1	20.4	20.5	+0.8
From capture fisheries (kg/year)	8.9	9.0	9.0	+0.5
From aquaculture (kg/year)	11.2	11.3	11.5	+1.8
FAO Fish Price Index (2014 – 2016 = 100)	2020	2021	2022 Jan-Apr	Change Sep 2022/Sep 2021
	94.9	101.7	124.0	+22.8

Thailand Talaad Thai Wholesale Market, Pathum Thani Province		THB per kg	
		Jul, 2022	Nov, 2022
Item		Price	
Chinese edible frog (<i>Haplobatrachus rugulosus</i>) (small)	กบนา (เล็ก)	100 - 105	90 - 95
Asian redbtail catfish (<i>Hemibagrus wyckioides</i>)	ปลากัดคั้ง	140 - 250	140 - 250
Yellow mystus (<i>Hemibagrus filamentus</i>)	ปลากัดเหลือง	125 - 150	125 - 150
Tire track eel (<i>Mastacembelus favus</i>)	ปลากะทิง	145 - 260	145 - 260
Clown featherback (<i>Chitala ornata</i>)	ปลากทราย	190 - 300	190 - 300
Iridescent mystus (<i>Mystus multiradiatus</i>) (large)	ปลาแขยง (ใหญ่)	150 - 160	150 - 160
Iridescent mystus (<i>Mystus multiradiatus</i>) (small)	ปลาแขยง (เล็ก)	100 - 130	100 - 130
Great white sheatfish (<i>Wallago attu</i>) (large)	ปลาเคี้ยวขาว (ใหญ่)	180 - 200	180 - 200
Great white sheatfish (<i>Wallago attu</i>) (small)	ปลาเคี้ยวขาว (เล็ก)	120	120
Bronze featherback (<i>Notopterus notopterus</i>)	ปลาฉลาด หรือ ปลาฉลาด	90	90
Farmed giant snakehead (<i>Channa micropeltes</i>) (large)	ปลาชะโด เลี้ยง (ใหญ่)	95 - 100	95 - 100
Farmed giant snakehead (<i>Channa micropeltes</i>) (small)	ปลาชะโด เลี้ยง (เล็ก)	60 - 80	60 - 80
Farmed North African walking catfish hybrid (<i>Clarias</i> spp.) (large)	ปลาดุกเลี้ยง (ใหญ่)	42 - 44	43 - 47
Farmed North African walking catfish hybrid (<i>Clarias</i> spp.) (small)	ปลาดุกเลี้ยง (เล็ก)	38 - 40	42 - 45
Siamese red catfish (<i>Phalacroglanis bleekeri</i>) (large)	ปลาแดง (ใหญ่)	300 - 350	300 - 350
Siamese red catfish (<i>Phalacroglanis bleekeri</i>) (small)	ปลาแดง (เล็ก)	140 - 170	140 - 170
Silver barb (<i>Barbonymus gonionotus</i>) (large)	ปลาตะเพียนขาว หรือ ปลาตะเพียนเงิน (ใหญ่)	48 - 50	48 - 50
Silver barb (<i>Barbonymus gonionotus</i>) (small)	ปลาตะเพียนขาว หรือ ปลาตะเพียนเงิน (เล็ก)	30 - 35	30 - 35
Red tilapia hybrid (<i>Oreochromis</i> spp.) (large)	ปลานิลแดง (ใหญ่)	80 - 90	70 - 78
Red tilapia hybrid (<i>Oreochromis</i> spp.) (small)	ปลานิลแดง (เล็ก)	60 - 65	60 - 65
Nile tilapia (<i>Oreochromis niloticus</i>) (large)	ปลานิล (ใหญ่)	50 - 55	48 - 55
Nile tilapia (<i>Oreochromis niloticus</i>) (small)	ปลานิล (เล็ก)	32 - 38	30 - 38
Whisker sheatfish (<i>Kryptopterus</i> spp.) (large)	ปลาชากไก่ (ใหญ่)	350 - 400	350 - 400
Whisker sheatfish (<i>Kryptopterus</i> spp.) (small)	ปลาชากไก่ (เล็ก)	120 - 140	120 - 140
Common carp (<i>Cyprinus carpio</i>) (large)	ปลาไน (ใหญ่)	35 - 40	35 - 40
Mekong giant catfish (<i>Pangasianodon gigas</i>)	ปลาบึก	60 - 65	60 - 65
Boeseman croaker (<i>Boesemania microlepis</i>)	ปลาฆ่า	200 - 350	220 - 350
Horse-face loach (<i>Acantopsis choirohynchus</i>)	ปลารากกล้วย	140 - 150	140 - 150
Giant gourami (<i>Osphronemus goramy</i>) (large)	ปลาแรด (ใหญ่)	90	-
Siamese mud carp (<i>Henicorhynchus siamensis</i>)	ปลาสร้อยขาว	32 - 35	32 - 35
Snakeskin gourami (<i>Trichopodus pectoralis</i>)	ปลาสลิด	100 - 190	100 - 190
Striped catfish (<i>Pangasianodon hypophthalmus</i>)	ปลาสาวย	26 - 30	30 - 33
Spot-fin spiny eel (<i>Macrogathus siamensis</i>) (large)	ปลาหลดจุด (ใหญ่)	200	200
Spot-fin spiny eel (<i>Macrogathus siamensis</i>) (small)	ปลาหลดจุด (เล็ก)	150	150
Rice-field eel (<i>Monopterus javanensis</i>) (large)	ปลาไหลนา หรือ ปลาไหลบึง นาข้าว (ใหญ่)	250 - 270	250 - 270
Rice-field eel (<i>Monopterus javanensis</i>) (small)	ปลาไหลนา หรือ ปลาไหลบึง นาข้าว (เล็ก)	300 - 320	300 - 320
Pond snail (<i>Filopaludina martsensi</i>)	หอยขม	45 - 130	45 - 130

Viet Nam Vietnam Association of Seafood Exporters and Producers (VASEP) Dong Thap in the Mekong Delta except black tiger shrimp (Da Nang)			VND per kg unless otherwise stated	
Item			Jul, 2022	Nov, 2022
			Price	
Pangasius (<i>Pangasianodon hypophthalmus</i>) (white flesh)	CÁ tra thịt trắng	0.7 - 0.8 kg	29,000 - 30,000	29,000 - 30,000
Pangasius fry (<i>Pangasianodon hypophthalmus</i>)	CÁ tra bột	Per fry (bột)	1.6 - 2.0	1.6 - 2.0
Pangasius fingerlings (<i>Pangasianodon hypophthalmus</i>)	CÁ tra giống	28 - 35 con/kg	27,000 - 28,000	32,000 - 33,000
Red tilapia (<i>Oreochromis</i> spp.)	CÁ điều hồng	> 300 g - 1,000 g	36,000 - 39,000	39,000 - 40,000
Red tilapia fingerlings (<i>Oreochromis</i> spp.)	CÁ điều hồng giống	35 con/kg	28,000 - 29,000	31,000 - 33,000
Snakehead (<i>Channa</i> spp.)	CÁ lóc nuôi	1.0 - 1.2 kg	36,000 - 38,000	38,000 - 40,000
Snakeskin gourami (<i>Trichopodus pectoralis</i>)	CÁ sặc rằn	8 con/kg	31,000 - 35,000	52,000 - 55,000
Climbing perch (<i>Anabas testudineus</i>)	CÁ rô đầu vuông	4 - 5 con/kg	33,000 - 35,000	37,000 - 39,000
Japanese wrinkled frog (Thai strain) (<i>Glandirana rugosa</i>)	Éch Thái	3 - 5 con/kg	42,000 - 45,000	39,000 - 41,000
Japanese wrinkled frog fry (Thai strain) (<i>Glandirana rugosa</i>)	Éch Thái giống	500 con/kg	400 - 450	600 - 700
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>)	Tôm càng xanh	15 - 25 con/kg	180,000 - 200,000	200,000 - 220,000
Giant freshwater prawn (<i>Macrobrachium rosenbergii</i>) P/L*	Tôm càng xanh post*	100,000 con/kg	NA	100 - 120
Black tiger shrimp (<i>Penaeus monodon</i>)	Tôm sú	15 con/kg	440,000	480,000
Black tiger shrimp (<i>Penaeus monodon</i>)	Tôm sú	25 - 30 con/kg	240,000	280,000
Black tiger shrimp (<i>Penaeus monodon</i>)	Tôm sú	40 con/kg	180,000	240,000

* all male

