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Trends in water chestnut farming

Integrated mangrove-shrimp aquaculture, Vietnam

Snow trout fisheries

Gender issues in Indian fisheries

AQUACULTURE ASIA

Aquaculture Asia

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NACA

An intergovernmental organisation that promotes rural development through sustainable aquaculture. NACA seeks to improve rural income, increase food production and foreign exchange earnings and to diversify farm production. The ultimate beneficiaries of NACA activities are farmers and rural communities.

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Aquaculture and the internet of things

For the most part, Asian aquaculture remains a low tech venture: Ponds, animals, feed and management. But things are changing. The advent of low cost embedded computers, sensors and wireless networking technologies are revolutionising the world; anything that can be automated is being automated; monitoring and management is increasingly being ceded to computer models and distributed sensor networks, AKA the "Internet of Things".

The hardware is (for the most part) cheap; for a few dollars you can buy a micro-controller – the kind of computer you will find in a hotel door lock – and various kinds of sensor. If so inclined, you can learn to program it yourself through online tutorials and support from online communities of enthusiasts.

Already you can buy off the shelf water quality monitoring systems that will stream data in real time to your phone or computer, manage aeration according to actual need (possibly resulting in substantial energy savings), issue an alert if something looks wrong and log all the data to the cloud, offering the possibility of analysis and insights that are presently unavailable to us.

Clearly, there are many potential benefits to be had from the internet of things", but there are also substantial risks that aren't being acknowledged in the marketing. As usual, aquaculture lags behind other sectors on the technology front, but if there is one benefit to being behind, it is that you get to see the mistakes that are made by those in front, and hopefully, learn from their experience.

A cursory survey of the state of the Internet of Things in the wider world quickly reveals one massive flaw: The state of computer security with these devices is beyond bad, it is simply dire. Whenever a security researchers scrutinise a class of IOT devices it is almost inevitable that a stream of security vulnerabilities will be found that allow unauthorised persons to access, manipulate and abuse them.

To the layman this sounds like science fiction. But on the internet, this is actually normal. Exposing what essentially amounts to an industrial control system to the internet, or to local wireless networks, is not something that should be done casually. Do you want random people to be able to remotely turn your aerators off in the middle of the night? Because if they can, they will.

And it gets worse. When a security problem is discovered on your PC, Microsoft will usually issue a fix within a few weeks and your computer will automatically update itself. But IOT devices seldom, if ever, receive software updates. Most don't have an automatic update mechanism and need to be patched manually. Manufacturers usually stop producing updates for 'obsolete' devices when new models become available, even though they are still useful and may remain in service for a decade or more.

If you are looking to buy some farm control or monitoring equipment, read the fine print. Warranties aside, how long will the company support the device for? Will they actually notify you if a security issue or serious bug is discovered? Is it possible for you to update the software or is technical expertise required? Does the wider system have redundancy, if a component stops working? If it has remote access capability, can you definitively turn that *off*? Is the data encrypted? Are commands authenticated? How can you restrict who has access to the system?

Simon Wilkinson

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Trends in water chestnut *Trapa bispinosa* farming in West Bengal, India

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Harvested purple-red and green T. bispinosa.

Characteristics of *Trapa bispinosa* fruit

Water chestnut *Trapa bispinosa* (or paanifol in Bengali vernacular) is a perennial aquatic herb and economically important crop of lentic freshwater bodies. It is commercially cultivated for its edible fruit in perennial ponds with low depth, wetlands and railway track-side water bodies. The fruit are harvested only in the post-monsoon until the beginning of winter (until the 3rd week of December in West Bengal). Leaf stalks of *T. bispinosa* hold air and the upper leaves, i.e., leaf crown develop as a rosette at each stem, with the apex kept afloat. Green or purple-red fruit bear a rough peel/skin with distinctive two sharp spines, one on each side at the same level, facing opposite directions.

Besides being nutritious and easily-digestible, water chestnut fruits are useful for patients suffering from jaundice, lower abdominal pain, diarrhoea and affections in connection with liver bile along with diarrhoea. Flatbread or Indian roti prepared from sun-dried and powdered water chestnut (grated chestnut kernel flour) is a traditional medicine for allergy and swelling of the arms and legs. Peeled raw fruit crushed and made into paste can relieve insect bites and stings if applied externally over the affected areas.

Position of fruit beneath leaves.

T. bispinosa in South 24 Parganas, West Bengal

Water chestnut is cultivated mostly in South 24 Parganas, Nadia (at Kalinarayanpur, Ranaghat, and Chakdaha villages), and Hooghly and East Midnapore districts, with the peak availability of fruits in November and December every year. In South 24 Parganas, since 2008-2009, water chestnut has been extensively cultivated and marketed in a well-organised manner at Hogla and neighbouring villages namely Bejra, Jugdia and Jangalia under the Joynagar-I Community Development (CD) Block, where a total of 400-550 farmers have adopted this profession as a means of livelihood, with 54-64 hectares water area under culture. Individual farming plots, demarcated and partitioned by white mosquito net and split bamboo fencing normally range between 480-3,000 m^2 in area (water depth: 75-180 cm) with the substrate typically a clay-rich soil covered in a thick layer of silt. Here *T. bispinosa* farming is a regular activity like any mainstream crop.

The author observed the state of farming practices of *T. bispinosa* in the stretch between the Hogla and Gocharan railway stations of the Sealdah-Lakshmikantapur railway route along both sides, and interacted with elderly *T. bispinosa* farmers. This region in Hogla Village is the nucleus of *T. bispinosa* production in South 24 Parganas; some farmers cultivate it in their own waterlogged land (*bada* and *jola maatth* in local dialect) while others lease areas for farming, that amounts to INR 8,000-10,000/1,320 m^2/year (equivalent to one bigha, a locally used unit of area). Additionally these farmers commercially cultivate guava fruit *Psidium guajava* on adjacent lands, which is usual practice. Brinjal and green chilli are mainly cultivated in this region during summer.

Sowing of *T. bispinosa* saplings

During mid-April to June, farmers produce healthy saplings of *T. bispinosa* (30-50 cm long) in large earthen bowls or water tanks (*mechhla* in local dialect; used to feed boiled hay and other supplements to cows) having a soil base, or in undisturbed 40-60 m^2 nursery ponds of 75-120 cm depth, where ducks do not swim. In such ponds low productivity is typical, so farmers apply 2.5-3.5 kg sundried poultry manure and NPK fertiliser (25-60-20). Desirable large-sized mature moist fruits are used as seed material. During early- to mid-June and a little later (pre-monsoon), slender *T. bispinosa* saplings are planted in bottom soil of main farming plots with at least 30-40 cm water depth after manual eradication of aquatic weeds *Eichhornia* sp and *Pistia* sp, freshwater snails and lime application. During June-July, around 2,000 saplings (@INR 2/piece) are planted per 1,320 m^2 plot at one metre spacing and 3,000-3,500 saplings are required if planted during late-July. Alternatively, at end of spring season, mature

Railway track-side plots at Hogla.

T. bispinosa farming plots.

fruit developed at the basal portion of rosettes (that remained unplucked) will drop off on its own into the bottom sediment of farming plot, and will give rise to a new plant.

T. bispinosa propagates from its side branches. As explained by farmers, the main stem produces several primary branch stems, and each primary branch stem produces a higher order of it. Numerous branching stems extend out to the water surface and the entire farming area is slowly and steadily filled with leaf crowns. According to a farmer, plants sown even at 4.5 m depth will rise through the water column up to the surface. About 700 *T. bispinosa* plants will be produced from 10 plants sown during the period end-May to end-July. In preparing cuttings, some farmers cut out 30-50 cm long segmental branch stems from the stock plant for use as saplings in farming plots @ 1,500-1,700/720-760 m^2 area. To carry out de-weeding and other works conveniently in deeper *T. bispinosa* plots, farmers use a 1 metre long floating platform indigenously made of halved bamboo placed in parallel to each other and fastened to two earthen water pots by their necks at both ends. The pots are upturned and hold air, serving as floats. Using this device, a respondent

Farmers removing aquatic weeds and snails.

Harvesting water chestnuts.

farmer harvests 35-40 kg of fruit every hour but the rate of harvest is more in shallow plots where the platform is not needed. At Erapur village in East Midnapore District, an elderly *T. bispinosa* farmer having a 2,400 m^2 plot ties four *T. bispinosa* cut-out branch stems at the bottom in a single knot, forming a bundle, and plants 150-180 of such bundles in the mud bottom. In Balasore district of Odisha state, about 4,400 to 4,500 bundles of *T. bispinosa* seedlings (3-4 seedlings in each bundle tied in a knot) are used for planting in a one hectare area[1].

Production and income

An elderly farmer explained that in a 1,320 m^2 plot, he harvests *T. bispinosa* from mid-October till the end of December six times at an interval of 12-13 days; 240kg are obtained in the first harvest and 640-720 kg in the subsequent harvests, provided sufficient and proper rainfall occurs from initiation of the culture period, which favours firm fixation of *T. bispinosa* in the mud and promotes good growth. Good harvests are obtained with onset of winter and mild cool weather. In every season (5-6 months), he invests INR 20,000 and gets an income of INR 40,000 from sale of marketable-sized *T. bispinosa* fruits (25 g size) in conditions of favourable weather and very good yield. For him, the profit margin is INR 20,000 and sometimes increased to INR 25,000. Another farmer harvests 220-240 kg of fruit on each harvest day from his 440 m^2 waterlogged plot (with favourable environmental conditions and good yield) having 60cm depth; a total of five harvests are made at an interval of ten days. He applies 5-6 kg urea and 5 kg diammonium phosphate four times each during culture period and Gromor 14-35-14 three times during the period. Gromor application beginning at the fruiting stage helps prevent blackish colouration of ripe fruits, this farmer opined.

A third *T. bispinosa* farmer stated that from every 1,320 m² plot in a season, at every ten days interval, 80-160 kg fruits are obtainable in the first harvest, 320-400 kg in the second, and 520-600 kg in each of rest four harvests. A fourth farmer owning a 2,800 m² plot (150-170 cm depth) stated that due to late arrival of monsoon in 2019, he will be able to harvest a total of 3,300-3,400 kg this season in all harvests at medium level of yield (3 pieces weighing 50 g). INR 25,000 is obtainable as profit from every 1320 m^2 plot but will be reduced to INR 12,000-14,000 in late 2019. He applies SPM once @ 175 kg/1320 m^2 area; 6-7 kg urea and 10 kg diammonium phosphate/1320 m^2 twice on the 30th and 50th day of culture. He stated that *T. bispinosa* may be produced in end-March (with onset of summer) and be ready for plantation if mature fruits are seeded in nursery plots in January. According to him and other farmers, application of 2 kg urea, 4.5 kg single super phosphate and 2 kg muriate of potash/1,320 m^2 at the time of sowing saplings before arrival of the monsoon gives good results. From the 60th day of culture until flowering

Farmers removing aquatic weeds and snails.

stage, a zinc-based micronutrient 'Chelamin Gold' is applied @ 0.5 g/litre 3-4 times at 15 day intervals. Urea is particularly essential when immature fruits appear on plants.

Both men and women are employed as labourers at time of harvest of *T. bispinosa* fruit. In this region, harvesting begins from around 5.30am and is completed by 10.00am and each labourer is paid INR 90-100/day for this duration. At times of good yield, 4-5 labourers working in a plot collect 350-360 kg of fruit per day, 2-5 fruits may be harvested from each plant. But at a low to medium level of yield, two labours will harvest 70-90 kg of fruits in two hours, each plant yielding around two fruit. With progress of colder weather and strong winter with persisting fog, harvest of *T. bispinosa* stops and the plants die off. If the arrival of strong winter and foggy weather is delayed, then the period of harvest may be extended and production is higher. According to a farmer, *T. bispinosa* traders (wholesalers) will buy the product @ INR 8-9/kg from farm site and the same will be sold @ INR 15/kg in retail markets in South 24 Parganas and the outskirts of Kolkata city. *T. bispinosa* fruit are sent to nearby and distant markets via road and rail within 11.00am-2.30pm on harvest days and will be sold by late evening in fresh condition.

On the first week of October, a *T. bispinosa* farmer at Hogla Village gets INR 40-55/kg from wholesalers which is the maximum price. Farmers are paid INR 32-36/kg produce on the grand occasion of Lakshmi Puja festival (3rd/4th week of October) and sometimes farmers get INR 55/kg fruit on the two days of this festival and same is sold in markets @ INR 80-90/kg. From end-October and till mid-December, *T. bispinosa* farmers get INR 20-29/kg produce, price falling towards end of season. The majority of fruits harvested in Hogla and afore-mentioned neighbouring villages are transported to wholesale markets at Baruipur Kacharibazar, Sealdah Koley market, Namkhana, Lakshmikantapur, Mathurapur, Sagar islands, Mograhat and Diamond Harbour in South 24 Parganas. Fresh produce has high market demand and the fruit loses its freshness (turns a blackish colour) if sold

Floating platform used to work in deeper farming plots.

after 24 hours from harvest onwards. A few advantageous farmers who had sown *T. bispinosa* plants in their plots using shallow groundwater pumps during end-March and early-April and begun cultivation are able to harvest fruits from end-September, which fetches them a high price.

De-weeding and other management practices

Aquatic pest snails (*Pila globosa*, *Bellamya* sp., *Gyraulus* sp.) are removed from *T. bispinosa* farming plots individually or using small locally-made nylon scoop nets as the snails destroy young *T. bispinosa* leaves. Growing aquatic grass and *Colocasia* sp. from peripheral areas is cut off; eradication of naturally-growing aquatic weeds *Lemna major*, *Lemna minor*, submerged *Naja* sp., *Hydrilla* sp. and *Ceratophyllum* sp. is strictly done routinely by hand-picking and sieving using scoop nets (hand nets) from water column during the culture period, which is a major component of proper management practice. Undesirable weeds consume nutrients of applied fertilisers, proliferate, occupy space and hamper growth of *T. bispinosa*.

According to farmers in Hogla village, the fishes *Clarius batrachus* and *Anabas testudineus* naturally thrive in these less-deep *T. bispinosa* farming plots and feed upon detritus food matter and aquatic insects. But non-judicious use of insecticides meant to protect *T. bispinosa* will kill these indigenous fishes.

Production in other districts of West Bengal

With an investment (i.e. expenditure) of INR 11,000-12,000 (including lease amount) in a 1,320 m^2 plot, each *T. bispinosa* farmer in Arambagh CD Block of Hooghly district makes an income of around INR 36,000 from sale of fruits (culture duration: 6-7 months) in conditions of good yield, thus net income being INR 24,000-25,000 and each farmer harvests 300 kg fruit every week from such plot during early-October to mid-December (Source: News published in Bengali daily 'Bartaman', 16/10/2019). Also at Singur, Goghat and Khanakul CD Blocks in this district, a large part of wetlands is utilised for *T. bispinosa* cultivation. *T. bispinosa* cultivation is well-known in railway jheels of Kamarkundu area in Hooghly[3].

At Kalinarayanpur village in Ranaghat-I CD Block in Nadia, farmers have practiced *T. bispinosa* cultivation for nearly four decades. According to a local farmer, INR 2,000 and INR 1,000 is spent for procuring *T. bispinosa* saplings and fertilisers-medicines respectively for every 1,320 m^2 plot and harvest begins from the third week of September; a total of

Close view of just-harvested fruits.

Washing and cleaning of fruits.

Weighing of washed fruits.

Freshly harvested fruits in sacks at Erapur village.

Weighed and packed fruits ready for transport.

1,000-1,200 kg fruit are obtained in five harvests. Fruit are sold @ INR 30/kg in the beginning, later reduced to INR 18/kg. Plants once sown will produce fruit for next twelve years via natural seed germination and reproduction (Source: News published in 'Anandabazar Patrika', 1/8/2014). At villages including Sahapur, Barduari, Arjuna, Talsur, Malior and Haldibari in Harishchandrapur CD Block of Maldah District, INR 5,000 is invested in every 1,320 m^2 plot and 1,000 kg of fruit obtained in a season, which is sold for INR 25,000. Net income for a farmer is INR 20,000/1,320 m^2. But they are seriously worried about high day temperature during late September-November, less rainfall and shrinking water resources in left-fallow ponds, canals and beels where *T. bispinosa* is under culture (Source: News published in 'Anandabazar Patrika', 3/11/2015).

A *T. bispinosa* farmer in Erapur village of East Midnapore harvests 6,000-6,500kg fruits in all harvests in a season from a 2,400 m^2 plot and his profit margin is INR 42,000-45,000. According to him, price soars to INR 70-75/kg at times of the Lakshmi Puja festival and Vishwakarma Puja (mid-September) in Howrah market and normally sell at INR 35-40/kg. He plants *T. bispinosa* saplings during May-June and experienced the same during July-August as less remunerative. As the spines of mature fruits are poisonous, some *T. bispinosa* pluckers get Tet-Vac injections just before second phase of harvest to protect from accidental injury caused while plucking fruits. The author also visited areas in Baruipara, Sibaichandi and Kamarkundu villages in Hooghly and Erapur, Khirai, Uttar Katal, Gajna and Bakharabaj villages under Ghoshpur GP in East Midnapore where *T. bispinosa* cultivation has flourished and is in vogue. A layer of 15-20 cm soft mud rich in organic matter at the bottom of a water body favours better growth of *T. bispinosa*[1]. With rising cost of medicines, fertilisers, labour and less-favourable weather, respondent farmers in South 24 Parganas opined that a profit margin @ INR 8,000-20,000/farmer/1,320 m^2/season is obtainable in *T. bispinosa* plots taken on lease and upto INR 34,000 in own and parental plots.

Epilogue

Impoverished and marginal households in Dalbari and Badeshwaria villages in Dewanganj upazilla of Jamalpur District in Bangladesh are getting Tk. 8,000-10,000/1,320 m^2 area as profit from *T. bispinosa* cultivation in flooded beels, where sowing the plants in deeper farming plots (160-210 cm) is quite tough. Wetland ecosystems flooded during monsoon, waterlogged borrow pits, waterlogged low-lying agricultural lands unfit for paddy, semi-derelict ponds and shallow ponds having high organic load can be utilised for cultivation of *T. bispinosa* where farming of economically-important freshwater fishes is not possible. Vegetables and other fruits rot or decay in farming plots but *T. bispinosa* does not; also poaching is impossible. As during the 3rd-4th quarter of 2019, paddy cultivators in Hogla, Bejra and neighbouring villages have suffered heavy loss due to unexpected late arrival of monsoon and heavy rain thereafter. But it has not affected *T. bispinosa* cultivation. A respondent farmer at Hogla had just harvested 1,750kg *T. bispinosa* from 4,000 m^2 plot on his third harvest on 27th and 28th October 2019. Several hundred rural families in West Bengal are engaged in this vocation and commercial farmers at Hogla and other afore-mentioned villages are helping in its extension.

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Improving livelihoods and increasing coastal resilience: A look at integrated mangrove-shrimp aquaculture in Vietnam

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Climate change in broader context: Southeast Asia and Vietnam

Shrimp aquaculture has been practiced in Asia for centuries but has seen significant expansion in Vietnam since the 1970s. Over the past forty years, shrimp aquaculture has become the most valuable seafood export in Vietnam. In 2017, shrimp accounted for 46% of seafood exports. Traditionally, shrimp aquaculture has been conducted through extensive farming methods. This is to say that farmers use large areas of land, generally on rice paddies, to rear fewer, high value shrimp. Recently, there has been a shift from extensive farms rearing black tiger shrimp (*Penaeus monodon*), to intensive farms rearing white-legged shrimp (*Penaeus vannamei*). Intensive farming occurs on much smaller plots of land and shrimp are grown in much higher concentrations— this, in theory, yields much higher returns per unit area.

Both of these practices are however not without fault from environmental and social standpoints. Both have come under fire for the deforestation of immense areas of mangrove forest. Between 1976 and 1992, shrimp aquaculture saw a massive boom (of ~3500%) which saw the largely unsustainable development of the industry. With this development came a significant loss of mangrove area. Between defoliants that were used in the American War, and the expansion of agriculture and aquaculture, mangrove forest area was decimated and reduced to only a fraction of what it had been. This was particularly notable in the Mekong Delta, which is home to approximately 70% of the mangrove stocks in Vietnam. The clearcutting of mangrove forest for shrimp farms is often a positive feedback cycle: Shrimp farms often become unusable after a period of time, forcing farmers to move on and clear cut more mangrove forest. While government regulations have improved the situation, the clearcutting of mangroves to make room for intensive shrimp farms remains a very real concern.

Pathways to improved livelihoods

One of the main social concerns surrounding shrimp farming in Vietnam is the ability to maintain a livelihood. Income from shrimp farms, particularly intensive farms, is often characterised by boom and bust cycles. When everything goes according to plan, shrimp farming can be a very lucrative career. However, epidemics, such as early mortality syndrome, and whitespot syndrome are extremely feared by farmers and can wipe out entire harvests in almost the blink of an eye. Higher stocking densities, ineffective wastewater management, and overuse of antibiotics due to the expansion of the shrimp aquaculture sector have only made these diseases more commonplace. If the right precautions aren't taken intensive shrimp aquaculture can be more comparable to gambling than farming as high input costs paired with very high risk can lead to loss of capital and bankruptcy. To make matters worse, in recent times, shipments of shrimp from Vietnam have been rejected by the FDA in the United States and the European Union due to trace amounts of illegal antibiotics.

Evidently, environmental and social sustainability is an issue when it comes to shrimp aquaculture in Vietnam. Recently, integrated mangrove-shrimp (IMS) aquaculture has emerged as a possible means of reaching both of those goals. IMS is an aquaculture practice that involves rearing shrimp in plots of land where mangroves are also grown. Standards are often set by the government or forestry companies, generally requiring 50-70% of the plot to be mangrove forest, while ponds and housing make up the other 30-50%. Generally plots may be set up such that mangroves are either separated or mixed within the shrimp farms. Some farms have even begun using mangroves as a means of filtering wastewater, ultimately diminishing the farms environmental impact. IMS farms more closely resemble extensive shrimp farming in the sense that *P. monodon* are reared at low stocking densities. While a fairly rudimentary practice, integrated mangrove-shrimp aquaculture has the potential to provide a more stable income than other forms of shrimp aquaculture practice— all while delivering tangible environmental benefits at near and far fields.

It goes without saying that sustainable livelihoods are of primary concern for farmers when deciding what type of aquaculture to engage themselves in. As mentioned, intensive shrimp farming may offer the opportunity for highly profitable returns on investment. However, the reality is that it is an extremely risky form of aquaculture to engage in, requiring a substantial investment in infrastructure alone. Furthermore, of the 2.4 million individuals involved in aquaculture in Vietnam, 75% of them are small scale farmers with farms smaller than 2 hectares; Evidently a large proportion of the farming population does not have the capital to invest in the technology or large quantities of feed needed for intensive aquaculture. There are a few ways by which IMS aquaculture has the potential to provide more stable livelihoods to farmers. First, IMS farming provides the opportunity for a more diversified income. While shrimp continue to be the primary species for income, IMS farmers can stock their ponds with crabs, clams, wild shrimp, wild fish and more. Furthermore, mangrove wood may be harvested at regular intervals to be sold. This diversification inherently allows for less reliance on shrimp and creates more protection from shrimp market downturns that otherwise can have huge effects on shrimp farmers.

Regulations set by forestry companies generally permit farmers to harvest mangrove wood after a 12 year growth cycle. This wood can then be sold for up to USD$310/hectare/year and is a way for farmers to diversify their income.

There have been several ways that the government and non-governmental organisations have been encouraging a transition from other forms of aquaculture to IMS. One such incentive is the implementation of Paid (Forestry) Ecosystem Services, a program that pays farmers for good environmental practice. In this case, because farmers are growing mangroves which are good for the environment, they are rewarded with additional income. For farmers that are contracted for 20 ha of land by forestry companies, this results in ~USD$500/year of income. Eco-certification is another means of receiving additional income as an IMS farmer. Eco-certifications are services generally indicating that a given product has attained a certain standard of sustainability. In the case of IMS systems, shrimp farmers can apply to be eco-certified— in the Mekong Delta, farmers usually apply as a group of farmers and as such reduce expenses. Shrimp that are reared and sold under eco-certifications will fetch a premium on the open market, creating incentive for farmers to become eco-certified. There are currently NGOs working with small-scale farmers in the Mekong Delta to increase the frequency of eco-certification.

Contextualising mangrove-shrimp aquaculture in climate change

Near field benefits

As previously mentioned, sea level rise is expected to be one of the biggest threats of climate change facing Vietnam. According to a recent report by the Norwegian Institute of International Affairs, Vietnam is one of the top ten countries expected to be the most impacted by climate change. This is due to the fact that Vietnam has large populations concentrated in low-lying areas. The Mekong Delta is one such area, lying at sea level with over 20 million inhabitants largely dependent on the land for subsistence. While there is much uncertainty surrounding the degree of sea level rise, models suggest that there will be at least 40 cm within the century depending on the degree of global warming. Even 30 cm of sea level rise would have huge implications for the low lying delta, likely displacing millions and having a huge impact on the livelihoods of many more; Vietnam is in need of a multi-faceted plan to combat this looming problem. Although political discussion has taken place regarding action required for sea level rise, IMS aquaculture has the potential to provide an innovative and sustainable soft option to combat the effects of climate change through processes inherent to mangrove forests.

Mangrove trees occupy the intertidal zone, and beneath every mangrove, there is a theoretical area called the ‘accommodation space’. The accommodation space can be defined as the space between the current soil level and the area in which soil can grow vertically and laterally. The accommodation space can gradually be occupied through the processes of sedimentation and accretion. Sedimentation is the process by which sediment is deposited onto the soil and accretion is the process by which that sediment is bound into the soil. Together, they ultimately increase the surface elevation of a given area. Sediment may be deposited in a variety of ways: Brought in during high tide, deposited from upstream river discharge, and even from the leaves from the mangrove trees themselves. Sea level rise is a very gradual process, occurring over many years and as such can be combated with another slow process in accretion. Studies have shown that in some cases, the rate of accretion can match the relative rate of sea level rise—particularly in delta areas where there is considerable sediment discharge from upstream. Reforestation of mangroves in the coastal provinces of the Mekong Delta by encouraging IMS aquaculture would be a means to combat the effects of SLR expected in the coming decades.

Far field benefits

IMS also has the potential to provide environmental benefits that extend beyond Vietnam. The primary driver of climate change is carbon dioxide emissions into the atmosphere. This creates the greenhouse effect whereby heat is effectively trapped in the atmosphere leading to increased temperatures over time. Like SLR, the degree of warming expected within the next century is uncertain, but appears to be between 1-4°C. A warmer climate may have huge implications for farmers, some effects are already being seen: an increased risk of disease, lower survivorship, and increased chances of extreme weather events such as typhoons. All of these will ultimately decrease the profitability of the farm and put livelihoods at risk. Carbon is removed from the atmosphere, or sequestered, through naturally occurring processes like respiration in plants, and passive absorption into the ocean. To reduce the rate of climate change, it is logical to try and increase the rate that carbon may be sequestered from the atmosphere. Reforestation of areas previously occupied by mangrove forest is one such way to increase sequestration.

Mangroves are among the best carbon sequesterers in the world. In fact, mangroves generally sequester over two times more carbon than boreal, temperate, or tropical forests. This is largely because of the tremendous amounts of carbon the mangroves store deep below ground. Even within our lifetime, reforested mangrove forests can sequester amounts of carbon comparable to forests that have existed for long time periods. A recent study conducted in Can Gio Mangrove Forest Park showed just that. Can Gio’s mangrove forests had been completely decimated during the Vietnam War due to the use of defoliants, but have recovered after reforestation efforts. If this concept is applied to a broader scale, reforestation efforts through much of the coastal Mekong Delta could help combat climate change though carbon sequestration.

Moving forward

In a period of time where industry rushes forward with little regard given to people or the planet, it is important to take sustainability into serious consideration. IMS aquaculture provides small scale farmers with an alternative to more risky forms of aquaculture by providing a steady, diversified income stream. Mangroves allow shrimp to be reared in a healthy and natural environment ultimately increasing survivorship and decreasing the risk of large losses through die-offs. Currently, IMS aquaculture is seeing expansion in Ca Mau province with support from international NGOs. The Government of Vietnam has encouraged the reforestation of land previously occupied by mangroves, but further support is needed to implement IMS farming at a larger scale. While some issues remain, such inequality in benefit sharing with the timber industry, things are steadily improving.

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Snow trout fisheries in Arunachal Pradesh of the Eastern Himalayas

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Left, right: A haul of S. plagiostomus at Dirang River

The natural aquatic resources of Arunachal Pradesh, lying in the eastern part of Indian Himalayan Region (IHR), is comprised of five major river drainages and numerous upland lakes, supporting a rich diversity of valuable cold water fishes, some of which are indigenous to the region and provides subsistence fisheries to the people inhabiting the area. Among the recorded indigenous species, snow trout are known for their economic importance and are recognised as potential species for food and recreation in the region. Very little information is available on their taxonomy, distribution, biology, habitat and food value. Considering these facts, an attempt has been made by the authors in this present communication to highlight the status of snow trout fisheries thriving in the snow fed streams, rivers and upland lakes of Arunachal Pradesh.

Snow trout are carps belonging to the subfamily Schizothoracinae and are classified as vulnerable in India by the IUCN (2012). The demand for this group of fish has increased drastically with increasing fishing pressure due to lack of sustained aquaculture alternatives in this hill locked part of the world. The coming decades are expected to pose newer challenges to the coldwater fisheries sector both in the development of aquaculture practices as well as conservation perspectives in the hill regions of the country with the concern for the indigenous fishes as candidate aquaculture species.

At present, the snow trout fishery in Arunachal Pradesh is mostly confined to the capture fisheries from the three major drainages viz., Kameng, Subansiri and Siang, the north bank tributaries of the river Brahmaputra. The other two drainages are Lohit and Tirap rivers, the south bank tributaries of river Brahmaputra having a comparatively tropical climate. Aquaculture of this group of fishes is at a lower level in Arunachal Pradesh and India more broadly, due to their inherent slow growth rate and lack of seed availability.

Seven snow-fed tributaries of Arunachal Pradesh have been explored by a team of scientists of ICAR-DCFR, Bhimtal, since 2016 with one fishing site on each tributary assessed to collect samples of snow trout for biological studies and record data on their habitat, abiotic and biotic environment, the catch composition and the fishing methods. Fishermen, local

Snow trout at the Sangti River.

Morphometric counts of snow trout from the Tenga River.

A haul of S. richardsonii from the Choskorong Kho River.

Snow trout from the Kiile River.

Catch of S. progastus from the Shei River.

residents and Fishery Officers were also interviewed to collect information on the abundance and catch details of snow trout. The tributaries assessed were:

- Dirang River (92°16'23"E, 27°22'30"N).
- Sangti River (92°37'22.4"E, 27°18'29.1"N).
- Tenga River (92°45'58"E, 27°18'15.7"N).
- Choskorong Kho River (92°27'32.8"E, 27°26'51.5"N) of Kameng drainage in West Kameng District.
- Kiile River (93°49'53"E, 27°33'18.2"N) of Subansiri drainage in Lower Subansiri District.
- Shei River (94°71'90"E, 27°99'08"N).
- Yargyap River (94°09'49.3"E, 28°34'32.4"N) of Siang drainage in West Siang District and Shi Yomi District respectively of Arunachal Pradesh in the Eastern Himalayas.

Snow trout composition

Snow trout are known as nga in local dialect and account for a major and important part of the capture fishery in the region. The dominant species of snow trout in most of the selected sampling sites of Kameng drainage were that of *Schizothorax plagiostomus* followed with *S. richardsonii*. Choskorong Kho River was observed to be dominated by *S. richardsonii* whereas *S. richardsonii* and *S. progastus* (McClelland 1839) were recorded in Shei River. Scanty information is available on snow trout from the Kiile River and Yargyap River in Lower Subansiri and Shi Yomi districts respectively due to remoteness of fishing sites and lack of transport facilities.

The average length of *S. richardsonii* was recorded as 14.64 ± 2.36 cm with an average catch size of 49.33 ± 21.52 kg in weight during the investigation in the different sampling sites of Arunachal Pradesh. *S. richardsonii* is distinguished by an

Snow trout, brown trout and other fishes from Yargyap River.

inferior and slightly arched mouth, hard cartilaginous covering below lower jaw extending between corners of mouth followed by a flesh and flat lower lip. The dorsal spine is strong and serrated behind.

In case of *S. plagiostomus*, the recorded average length was 17.32 ± 4.89 cm with an average catch size of 54.36 ± 33.92 kg in weight. The fish has a projected snout, mouth distinctly

A maximum size snow trout from the Kameng drainage.

Fig. 1: Average length (cm) of snow trout from different sampling stations.

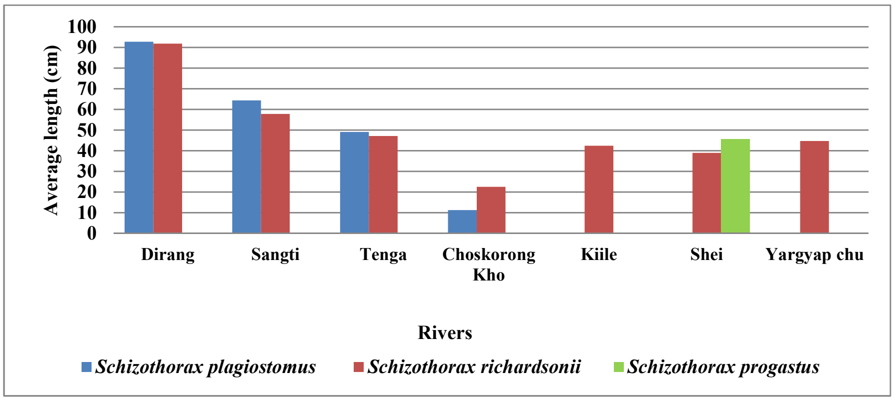
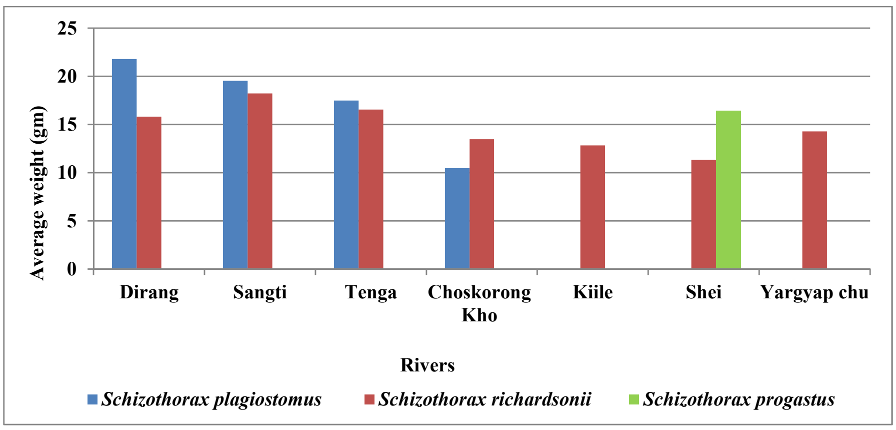


Fig. 2: Average weight (g) of snow trout from different sampling stations.



inferior, lower jaw very wide and deep, short and with a sharp keratized anteroventral cutting edge, lower lip fold expanded and papillose.

S. progastus recorded an average length of 16.44 ± 1.02 and an average weight of 45.63 ± 14.34. The mouth of the fish is protractile, lips thick and fleshy, lower labial fold uninterrupted and trilobed, median lobe insignificantly small. The dorsal spine is strong and serrated behind.

The maximum length of the fish recorded in these snow fed tributaries of Arunachal Pradesh was 52.5 cm weighing 1.20 kg. The snow trout constitute an important part of capture fishery in the region and form a major component in the diets of the local people. The average length and weight of *S. richardsonii*, *S. plagiostomus* and *S. progastus* captured and recorded from different sampling stations are shown in figures 1 and 2. Fishes such as *Garra* sp. *Glypthothorax* sp, and *Psilorhynchus* sp. loaches were also captured from different sampling stations but in limited numbers. Cypriniformes represents 44% of the catch in the rivers of Kameng drainage, which are dominated by the snow trout group (Fig. 3). *Schizothorax* species represent 15% of the total catch composition in Shei River (Fig. 4). Yargyap River in Shi Yomi District recorded a major catch of

Fig. 3: Distribution of fish orders in Kameng drainage.

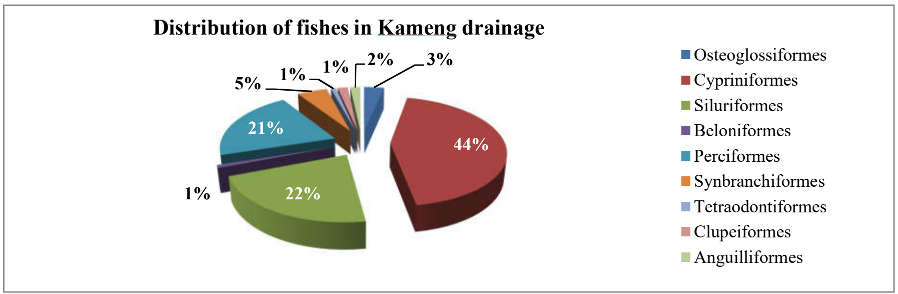
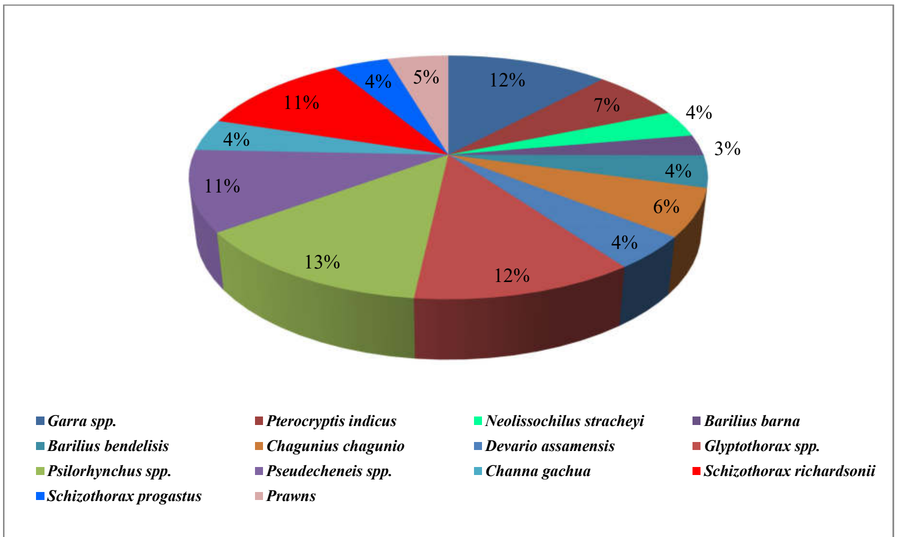


Fig. 4: Percentage distribution of fish species in Lipums operated in the Shei River.



brown trout (*Salmo trutta fario*) and the snow trout are restricted to upstream tributaries of the main river.

Snow trout fishing methods

The fishers of Arunachal Pradesh are neither inborn fishers nor belong to any fishing community and therefore fishing of snow trout is restricted on traditional lines. This group of fish is not harvested commercially reasons for export and thus the catch is usually consumed locally for household usage. It was observed that the fishing gears applied for catching snow trout are mostly indigenous and specific to a particular area depending on the nature of the river and skills of the tribespeople operating the gears.

Noose and line: This method of fishing is selective for catching snow trout inhabiting the deeper pools and turbulent lotic water of Dirang and Sangti rivers. This fishing device consists of a rod, reel, long-line with nooses, rings, bait and weight. The rods are made of bamboo measuring 2.5-5.0 m in length and 0.9-3.2 cm girth diameter and the lines are made of nylon monofilament material of 0.30-0.41 mm diameter. 7-20 nooses are prepared on one line, keeping an space of 5-8 cm in between. The reel in this gear is unique of its kind as it is prepared indigenously imitating a professionally designed one used by avid anglers. The reel is not supported by an actual wheel and a lever to cast and retract the monofilament line. Instead, the reel is made of an aluminium wire of 2-3 mm diameter in thickness and attached firmly to the rod by rubber strips. The line contains 1-3 of baits made of lead material and is attached few centimetres above the anterior most nooses on the line. A sinker, usually a stone weighing 100-250 g in weight is tied to the line for proper dipping of the loops in water. The gear is mostly operated during November to February when water is mostly clear and transparent. Average catch per unit effort (CPUE) of the gear was recorded to be 1.8-2.2 kg/h and average catch size in weight was 136.3 ± 116.34 kg. Noose and line fishing is highly energy efficient and accounts for high fish quality with low investment.

Cast nets: Cast nets are most frequently operated in the fast flowing rivers of Arunachal Pradesh. The nets are made of multifilament and are heavily weighted around the base by fixing iron weights to the free edges of the pockets and each is provided with a retrieving line attached to the apical portion. The CPUE of cast nets vary widely from 0.5-5.2 kg/per hour/ gear. Cast nets are operated round the year. Monofilament cast nets are also operated in the region but have a low durability. The mesh size of the cast nets varies from 1.5 to 2.5 cm.

Damming: Partial damming on the Choskorong Kho River is another technique for catching snow trout in the Shergaon region of West Kameng District by local fishers. Short dams are constructed manually across the entire breadth of the river with rocks and boulders found on the river bed. This process of damming the river is called *kholeya* (*kho = water*; leya = enclosure) in local language and is practised during the pre-monsoon season when water level starts rising during the month of March-April. The bark of oak tree and walnut are ground and an extract is prepared out of it. This extract serves as a fish poison and its application in water slows down the movement of the fishes or temporarily paralyses thems. The catch is erratic accounting a CPUE of 2.0-15.0 kg/day and the fish is either consumed locally or is sold at a price of Rs. 300-400

Water diversion: This is another method of fishing on the Choskorong Kho River, where water is diverted towards a bamboo passage, locally called as *neuta* (*neu* = fish and *ta* = place). This method of fishing is mostly seen during the post monsoon season whence the water starts receding and the fishes migrate downstream during September-October after spending a considerable time upstream during monsoon. The diversion of river water causes the flow to pass through the bamboo passage with the fishes. The water percolates through the bamboo mesh whereas the fishes remain within the platform. An average catch of 0.5-4.2 kg/day has been recorded in this method of fishing.

Noose and line method at Dirang River.

Fishing for snow trout by cast net at Sangti River.

Fish trap: *Hoap* is a kind of tubular shaped fishing trap which is well fabricated of bamboo. One of the ends has a non-retractable mouth piece guarded with inwardly pointed labyrinths. The tail end has a similar kind of labyrinths but is outwardly projected. The fishes once entering the trap are neither able to retract back through the mouth nor escape from the tail end. The mouth part has a diameter of 15-30 cm and the length of the trap varies from 40-90 cm. These traps are placed over night against the flow of stream water and the fishes are harvested in the early morning hours of the day. A maximum CPUE of 2-4 kg/day/gear is recorded in this gear.

Fish aggregating structures: *Lipums* are the only method of capturing fishes in the river systems of the Basar area situated at mid-altitude 594-787 m of West Siang District. These are installed by aggregating stones and boulders from the river bed, engrossing an area of 1.5-2.0 m^2 to lure fish naturally seeking for shelter, protection from predators and in search of food adhering to the structures. The lipums are operated during winter season having a water level within one metre depth and relatively less water flow. Fish harvesting from the lipums is done by two indigenous made bamboo devices, a rectangular shaped mat eechir is used to encircle the lipums and funnel shaped traps kabulu or odur measuring 0.7-1.0 m in length and 0.08-0.20 m girth diameter are used to retrieve the fishes alive and intact. A local biodiversity conservation society, GRK, ensures the protection of the river biodiversity by restricting lipums as the only means of fishing. The relative abundance of aggregated fishes in lipums was higher for those having inferior or adhesive mouths (70%) viz., *Garra* spp., *Pterocryptis indicus*, *Schizothorax* spp., followed by shiners (30%) viz., *Channa* spp., prawns and sporadically *Neolissochilus stracheyi*, *Chagunius* spp. and lesser barils, yielding an average catch of 2.5-12.0 kg per lipum. Altogether, fishes aggregated in lipums belonged to four orders, six families and fourteen species. The major species of snow trout recorded in the lipums are *S. richard-sonii* and *S. progastus*.

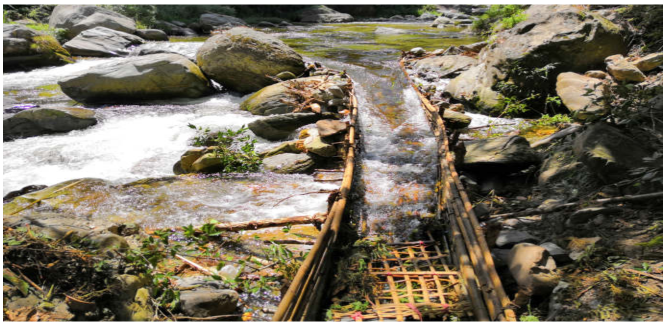
Snow trout habitat

Overall, the topography of the river sites is hilly in nature with steep slopes, situated at an altitude ranging from 1,411-1,934 metres. All these rivers are perennial and arise along the Indo-China border and in their total route confluence with many major and minor tributaries and carry all of the discharge to the Kameng, Subansiri and Siang basins. The dominant stream substrate in the Kameng drainage consists of large boulders along the banks and small boulders, cobbles and gravels on the beds. The Kiile and Shei rivers have small cobbles and pebbles along most of their length. The Yargyap River has small boulders along the banks and pebbles and gravel at the bed. Furthermore, the rivers of Kameng drainage feature mostly riffle and deep pools, the Shei and Kiile rivers shallow pools and runs, and the Yargyap River deep pools and riffles and runs in certain stretches.

Abiotic variables of water: The abiotic variables of water from the sampling stations were analysed with standard methods. All the sampled river sites of Kameng drainage and Yargyap River, being snow fed in origin, remained clear and transparent during the study period. Most of the essential water quality parameters were within the optimum level indicating good health of the water body and conducive conditions for the abundance of the snow trout. On this basis of alkalinity studied, the rivers fall under the category of moderately nutrient rich (Spence, 1964) and the measure of hardness (Moyle, 1946) reveals that water of the river sites are soft except in the Tenga, Choskorong Kho and Kiile rivers, which may be attributed due to higher human population around the sampling sites.

Biotic variable analysis of water: Phytoplankton in the river ecosystems at different sampling locations was estimated. Altogether, 30 species of plankton were identified belonging to 24 families, 19 orders and 6 classes from the upland rivers of Kameng drainage. The species of *Navicula* (27%) dominated in Dirang River followed by *Oscillatoria* (23%) and *Nitzschia* (18%); *Meridion* (36%) dominated in the Sangti followed with *Nitzschia* (26%) and *Fragilaria* (17%); *Spirogyra* (50%) dominated in Tenga River followed with *Nitzschia* (17%) and *Pinnularia* (14%); *Stigeoclonium* (23%) dominated in the Choskorong Kho River followed with *Nitzschia* (17%) and *Anabaena* (14%) and *Spirogyra* (24%) dominated in Kiile River followed with *Spirulina* (12%) and *Nitzschia* (11%). *Anabaena* (34%) dominated in Shei River followed with *Spirogyra* (22%) and *Navicula* (17%); *Oocystis* (43%) dominated in Yargyap River followed with *Stigeoclonium* (21%) and *Nitzschia* (12%).

Damming the river to facilitate fishing.



Operation of neuta over the Choskorong Kho River.

Food and feeding habits

The availability of food in fast flowing streams is a determining factor for distribution of the snow trout fishes in terms of their energy requirement for growth, development and reproduction. Snow trout is a phytophagous fish having transverse inferior mouth adapted for scraping attached algae from the

Fishing for snow trout with lipums in the Shei River.

Operation of neuta over the Choskorong Kho River.

Fishing for snow trout by cast net at the Sangti and Tenga rivers.

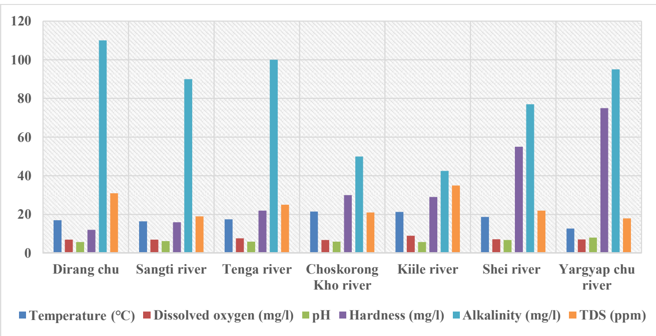
Table1: Gut content analysis (plankton abundance in gut) of the snow trout at the sampling stations in different rivers.

	Dirang chu		Sangti		Choskorong Kho		Tenga		Kiile	Shei	Yargyapchu
Species	**SRi**	**SPl**	**SRi**	**SPl**	**SRi**	**SPl**	**SRi**	**SPl**	**SRi**	**SPr**	**SRi**
Pinnularia	***	**			*	*	***	***	**	**	*
Navicula	**	**	*	**	**	***	***	***	**	***	**
Fragillaria	**	***	*	**					***		**
Chlorella	*	***		*					*	*	
Oscillatoria	*										
Cocconies		**							*	*	
Meridion			**	***		*	*	*	*	*	*
Nitzschia			**	***	**	**	***	***	***	***	
Achnanthes					*	*	**	***	*	**	***
Spirogyra							**	**	**	***	
Cymbella					**	**	*	*			
Stigeoclonium	**				***	***					**
Cladophora		*									
Oocystis			***	***							***
Achnanthes			*	*			**				***
Diploneis			*	*							
Eunotia			*				**	*	*	*	*
Synedra				*		*			*	*	*
Tabellaria					*						
Cymatopleura							*	*	*	*	
Dyctyospharium							*	*			
Spirulina									*		
Anabaena										*	

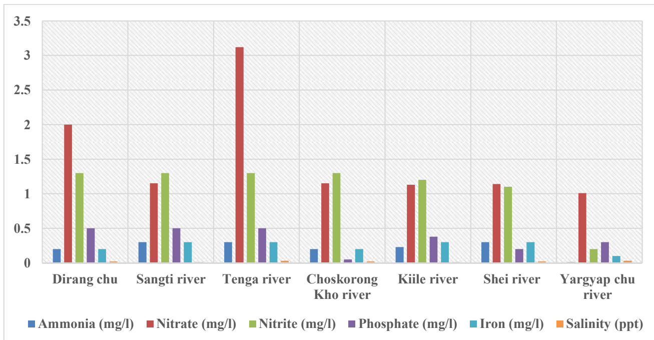
SRi: *Schizothorax richardsonii*; SPl: *S. plagiostomus*; SPr: *S. progastus*

***High; **Moderate; *Least

Graphical representation of physico-chemical parameters of water at sampling stations.



Graphical representation of nutrient variables of water at sampling stations.



surfaces of stones. The gut content of *S. richardsonii* and *S. plagiostomus* is comprised of phytoplankton and their abundance is stated in Table. 1.

The snow trout breeding in the rivers

Field observations on the different stages of the reproductive organs reveal that the percentage of mature specimens was mostly recorded during May to August. The occurrence of the mature individuals in these months indicates the proximity of spawning period. The matured ovaries in females are yellowish in colour with a reddish tinge due to the increased vascular supply. The ovaries further increase in volume and weight and cover nearly the entire length of the body cavity. On the other hand, the mature testes in males become very thick, creamy white in colour with oily surface, are lobed and extend to two thirds of the body cavity. A slight pressure on the belly releases milt from the genital papilla.

Aquaculture of snow trout

Aquaculture of snow trout in Arunachal Pradesh has not gained much popularity due to its slow growth rate and non-availability of hatchery produced young ones in useful numbers. However, seed are being procured from natural river water and stocked in small sized ponds and tanks by local fish farmers, due to the lack of a fish hatchery for producing fish seed of other commercially important fishes such as carps and catfishes. A few progressive farmers procure carp seed from other neighbouring states but then the unit price of the carp seeds rises manifold due to on-road transportation charges. Furthermore, survival and growth

Fishing for snow trout with lipums in the Shei River.

Sampling site at Tenga River.

of carps is lower due to the colder regime of the region. Snowtrout seed (5-9 cm) are collected by sieving with cloths or sieves during the post-monsoon season (August-September) and are stocked in the ponds. The ponds are usually smaller in size measuring 100-1,500 m^2 depending on the slope and the topography. The ponds are provided with a continuous water flow through an inlet pipe from a stream source. Manure or fertilisers are not used for plankton production. Fish feeds are provided with local ingredients and household left overs which include maize flour, crushed maize remains, cooked rice, buckwheat flour, finger millet waste and wheat balls. An average fish weight 150-200 g was estimated after one year of rearing. There is no season of harvesting the fishes and are consumed locally round the year.

Sampling site on the Dirangchu River.

Sampling site at the Sangti River.

A gravid female snow trout.

Study area in an upstream tributary of the Yargyap River.

A mature male snow trout.

Study area in an upstream tributary of the Yargyap River.

Snow trout marketing

Snow trout are seldom sold in fresh conditions at local markets. The fresh fishes are usually sold to the villagers residing adjacent to the harvesting sites. The snow trout intended for sale at markets are smoked and preserved on a raised platform over a fireplace in the household kitchens so as to increase their shelf-life up to six months. These smoked fishes are packed in a small bunch consisting of 5-6 fish or into a bigger bunch of 10-12. The fishes are carried to the local markets packed in perforated bamboo baskets. In other cases, the whole fish is inserted onto a bamboo needle from mouth to peduncle for ease of handling. The fish are sold at the rate of Rs. 500 for the smaller bunches and Rs. 1000 for the bigger bunches. In restaurants, the fishes are preserved by slicing them into fillets and then hanging them on a wire over a fireplace for smoking. These smoked fish are then ground to serve as a paste blended with spices. The freshly caught fishes are also served as fishfries and fish curries.

Above, below: Riverine collection of snow trout seed.

Above, below: Release of wild-collected snow trout seeds in confined ponds.

Above, below: Preserved snow trout for sale in local markets.

This column: Aquaculture of snow trout in various pond configurations, Arunachal Pradesh.

Preserved snow trout for sale in local markets.

Snow trout served in restaurants.

Conclusion

Snow trout are very highly valued as sport and food fish in Arunachal Pradesh of the Eastern Himalayas. The catch of the snow trout is mostly confined to natural river drainages. The local people residing along these drainages could benefit by adopting to fish-based ecotourism ventures. Snow trout fetch a high price compared to carps and catfishes in the region. But to raise the fish in captivity needs proper feeding strategies and seed production protocols and this holds the major challenge for research. Therefore, overcoming the difficulties of ready feed and seed availability in the region, the young ones can be stocked for aquaculture and can also be released into the natural systems for their self-propagation.

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Gender issues in the fisheries sector of India

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Currently, India is the second-largest fish producing country in the world and second-largest aquaculture producing nation. With regards to aquaculture, India is also a major producer of fish, second after China. Total fish production during 2016-17 ws 11.41 million metric tonnes (mmt) with a contribution of 3.64 mmt from the marine sector, and 7.77 mm from inland. Fishing and fish farming in India is a primary industry and provides employment to over 14 million people. India's freshwater resources consist of 2.9 million hectares of minor and major reservoirs, 2.4 million hectares of ponds and lakes, 195,000 kilometers of rivers and canals, and around 800,000 hectares of flood plain wetlands and water bodies.

Women play an essential role in the fisheries sector in India. They make an immense contribution by engaging in varied activities. They may engage as paid or unpaid workers both in pre and post-harvest activities, in seafood processing plants, as caregivers of the fisher family - maintaining social networks and culture of the community and as members of fish worker movements and fisher's organisations such as the International Collective in Support of Fishworkers. However, the extent to which interests, needs, and concerns of fisher-women are given attention is questionable. Because of this reason, the need for gender studies and mainstreaming gender equality in the fisheries sector is highly necessary.

Although women perform a significant part of the activities in agriculture and allied industries, their contribution often remains invisible or understated. Women are burdened with triple responsibilities or roles, referring to the productive, reproductive, and community management roles that they perform. Productive tasks include the activities undertaken for producing goods and services also for sale, exchange, or to meet the current needs of the family. Reproductive roles include actions required for maintenance of household and reproduction of society's labour force. Examples are child rearing, care of family members, socialisation of young, cooking, and so on. Community roles are an extension of women's reproductive roles to ascertain the maintenance and provision of limited assets of collective consumption, such as health care, education, water, and fuel. Both men and women play multiple roles. However, there is a significant difference in that men tend to perform their work sequentially, but women usually play their roles simultaneously, balancing the demand within their limited time constraints (ILO). In the Indian Himalayas, it is estimated that over the course of a year on a one-hectare farm a pair of bullocks works an average of 1,064 hours, a woman works 3,485 hours, and a man works only 1,212 hours, a figure that illustrates the significance of women's contribution to agricultural production. (Shiva FAO, 1991).

Gender is a means of understanding how society operates through the study of the negotiation of power roles and influence between men and women. Despite the considerable efforts at promoting gender equality and gender mainstreaming within the organisational structures of policymakers and change agents, there are still considerable gaps in our knowledge of gender relations in the fisheries sector and how these are affected by the change (Bennette, 2004). Even with the growing recognition that women do fish, there remains an imperative to engage in more meaningful and relevant gender analysis to improve socio-ecological approaches to fisheries research and management. Beyond gender difference in fishing practices throughout the world, the literature reveals a quantitative data gap in the characterisation of gender in small-scale fisheries (Kleiber, 2015).

What is meant by gender issues in fisheries?

Gender issues refer to any issue determined by gender-based differences between women and men fishers.

It includes all concerns related to women's and men's:

- Lives and their situation in society.
- Way to interrelate each other.
- Differences in access to and control over resources.
- Activities in fisheries, and response to changes, interventions and policies.

Although women contribute heavily in the sector, their work is often referred to as 'invisible' and does not receive due recognition. The percentage of women in the fisheries workforce is 46 % globally and 72% in India (FAO, 2016). The fisher population sex ratio is 928 women to 1,000 men in the maritime states of India (CMFRI census). Among the women engaged fishing-related activities in India, 57% participate in fish seed collection, 73.6% in marketing, and 75.7 % in curing and processing (CMFRI, 2010). The Central Institute for Women in Agriculture (CIWA) has calculated the Gender Work Participation Disparity Index in fisheries which varies from state to state. In Nagaland, Manipur, and Himachal Pradesh it is < 0.15, whereas in Punjab, Haryana, Kerala, Uttar Pradesh, Bihar, and Odisha, it is between 0.34 and 0.59 (CIWA, 2015).

Inappropriate facilities and support services

Most workplaces, especially processing industries, mostly engage women employees. Rigidity in working hours causes difficulties for women because they are burdened with household responsibilities. If the place of work is far away, then it is too difficult for women to attend work on time. Women mostly engage in post-harvest activities; they are prone to injuries, for example, in peeling operations. Moreover, unhygienic working conditions, lack of safe drinking water, lack of health care, and poor sanitation are among other problems.

Limited access to resources

It is seen that ownership of land and other productive resources mostly belongs to men. Statistics reveal that women's ownership of land is only 20% in developed countries and a mere 2% in developing countries (FAO, 2011); for this reason, women also lack access to credit facilities. As they require ownership of land and other productive resources as collateral, they are unable to avail credit from lending agencies. Marketing arrangements are not accessible to women because of long-distances or male dominance. Recent technological advancements in agriculture and allied sectors have focused on men as the primary stakeholders drawing women behind. So there is a lack of women-friendly technologies in the sector. Women have limited reach in availing benefits from the extension machinery. Only 5% of all agricultural extension services were received by female farmers from 97 countries, only 15% of world's extension representatives are women, and only 10% of total aid for forestry, agriculture, and fishing goes to women (FAO, 2011).

How is male migration a gender issue in fisheries?

Firstly, considering the case of male migration to other places for work, leaving women at home. In such a situation, the sole responsibility to look after the household falls on women. Furthermore, women also have to engage in earning activities if remittances sent by their partner is not sufficient. If male members of the household go deep-sea fishing, then remittances that can be received are nil for the duration of the voyage, which may cause overburden of work for women.

Another situation is male immigration. This happens in profitable ventures where women are engaged. Examples of such ventures are the collection of oysters and shells. Males migrate to such areas and take up similar activities, thereby reducing the earning possibilities of local women.

Less participation in decision making and unequal share on benefits

Women have been absent from formal decision-making platforms in fisheries, making it difficult for their livelihoods and well-being to be addressed. Sustainable transformation can be achieved if all community members, including women, participate actively in development projects. Work patterns of women include unpaid and low paid work in fisheries which are not accounted for. Proper recognition of the 'invisible work' of women is necessary to account for their contribution to the fisheries sector.

Suggestions to address gender issues

Gender disaggregated data collection is encouraged to create a clear picture of the contribution of both men and women and give due recognition to the so-called 'invisible' work of fisherwomen. This can be accelerated by gender-responsive research and gender mainstreaming course curriculums in fisheries education. Sensitisation of fishing communities on gender issues is necessary so that men do not disregard the needs, interests, and concerns of women, and women themselves become aware of their own needs and participate actively in different activities to gain benefits on an equity basis. There is a need to develop women-supportive marketing infrastructure to involve more women in the marketing chain. Collective efforts prove to be very successful. Women can participate in self-help groups and make effective use of microfinance to initiate start-up enterprises or to supplement their contribution to household income. Therefore, the formation and strengthening of women self-help groups should be encouraged. There is a need to facilitate women's access to credit and finance. Gender perspectives in fisheries are essential to upholding the needs and interests of both the genders. It can thus be a holistic approach, covering all primary production and allied sectors. There is a need to analyse and put the issues in proper perspective, generate sufficient, relevant data and transparent policies to target development action.

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Cooperation with the Bangladesh Shrimp and Fish Foundation

Left to right: Dr Cherdsak Virapat, Executive Director of ITD (and former NACA DG), Dr Imtiaz Ahmed, a Director on the BSFF Executive Committee, Dr Huang Jie, present Director General of NACA, and Dr Eduardo Leano, Coordinator of NACA's Aquatic Animal Health Programme.

The NACA Secretariat had the privilege of hosting a delegation from the Bangladesh Shrimp and Fish Foundation (BSFF) to discuss opportunities for further cooperation under the Memorandum of Understanding previously signed by BSFF and NACA in May 2018. The delegation consisted of Dr Imtiaz Ahmed, a Director of the BSFF Executive Committee who is very well known within the network, and Dr Cherdsak Virapat, the previous Director General of NACA and now a member of the BSFF Advisory Committee and Executive Director of the International Institute for Trade and Development under the Thai Ministry of Commerce.

Discussions were wide ranging but BSFF and NACA will examine opportunities to continue to facilitate technical training of Bangladesh personnel on *P. monodon* culture, and long-term institutional capacity building. Strengthening capacity in aquatic animal health management is another area of mutual interest where NACA can broker sharing of experience and technical expertise from within the network and member states.

NACA appreciates the partnership with BSFF and the rewarding collaboration that has taken place to date in improving the capacity and livelihoods of small-scale farmers and related businesses, and looks forward to building on these initiatives.

Separately, NACA has just opened discussions on areas of potential collaboration with the International Institute for Trade and Development, with details to follow in due course.

Global Conference on Aquaculture 2020 update

Preparations for GCA2020 are ratcheting up with the International Organizing Committee meeting in the margins of the recent Tenth Session of the COFI-Sub-Committee on Aquaculture, 23-27 August 2019, Trondheim, Norway.

A series of flagship reviews have been commissioned on the status of aquaculture development in different parts of the world. The conference will kick off with presentation of these regional reviews and a global synthesis, to provide context for the thematic reviews and expert panel discussions that follow.

The full technical programme and details of speakers will be announced shortly.

Quarterly Aquatic Animal Disease Report, January-March 2019

The 81st edition of the Quarterly Aquatic Animal Disease report contains information from twelve governments. The foreword discusses the proposed Regional Collaboration Framework on Aquatic Animal Diseases in Asia and the Pacific. This will initially focus on building a framework of actors with the aim of strengthening laboratory capacity for aquatic animal disease activities in Asia and the Pacific, for example to support emergency response.

The report is available for free download from:

https://enaca.org/?id=1061

A fresh look at inland fisheries and their role in food security and livelihoods

Simon Funge-Smith (FAO) and Abigail Bennet (Michigan State University)

Abstract

The role of inland fisheries in livelihoods, food security and sustainable development is often overshadowed by the higher profile interest in ocean issues. Whilst inland fisheries' catch and contribution to global nutrition, food security and the economy, are less than that of marine fisheries, global-level comparisons of fish production obscure considerable livelihood impacts in certain countries and sub-national areas. To highlight these contributions, this paper synthesizes recent data and innovative approaches for assessing such livelihood contributions and their importance in countries with limited access to ocean resources and aquaculture. Inland fisheries are crucial for many socially, economically and nutritionally vulnerable groups of people around the world, but the challenges in monitoring inland fisheries preclude a complete understanding of the magnitude of their contributions. This situation is rapidly improving with increasing recognition of inland fisheries in development discourses, which has also encouraged research to enhance knowledge on the importance of inland fisheries. We review this work, including collated information published in a recent Food and Agriculture Organization report, to provide an up to date characterization of the state of knowledge on the role of inland fisheries.

Full article available on an open-access basis from the journal Fish and Fisheries (2019; 00:1-20):

https://doi.org/10.1111/faf.12403

Tuskfish 2 Beta: Testers wanted

Tuskfish has progressed to beta status with the first public release expected before the end of the year. Tuskfish 2 is a rewrite of Tuskfish CMS, the software that runs the NACA website. It is distributed for free under the GNU General Public License V2. Tuskfish 2 builds on the experience gained in the first version to produce a faster, leaner and more efficient code base. Additional changes since the alpha (see last issue) include:

- Adoption of the DICE dependency injection container.
- Abstraction of the tagging and metadata systems into traits to facilitate reuse.
- Convert session system to non-static implementation.
- Add admin-side search functionality to facilitate content management.

If you're interested in helping to test Tuskfish 2 in a voluntary capacity please send an email to simon@enaca.org.

You will need to have your own infrastructure and previous experience in operating a content management system (eg. Wordpress, Joomla, Drupal etc). However, Tuskfish can also be set up locally on a PC with XAMPP or equivalent in a couple of minutes. I would also be interested to hear from people interested in trying to install it on alternative webservers such as NGINX or IIS.

APAARI Regional Workshop on Underutilized Fish and Marine Genetic Resources and Their Amelioration

NACA participated in a regional workshop held in Colombo, Sri Lanka from 10-12 July, convened by the Asia-Pacific Association of Agricultural Research Institutions, Sri Lanka Council of Agricultural Research and Policy, Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources, Council of Agriculture, and Australian Centre for International Agricultural Research; in collaboration with the Sri Lankan National Aquatic Resource Research and Development Agency, National Aquaculture Development Authority, Marine Environment Protection Agency and Ministry of Fisheries and Aquatic Resource Development and Rural Economy.

The scope of the workshop was very broad, in the sense that it addressed genetic resources in different contexts. These included fishing, bycatch, by-products and discards; aquaculture, genetic management of broodstock and development of improved lines; conservation of genetic resources and biodiversity; bioprospecting, chemical and pharmaceutical application; intellectual property rights and access and benefit sharing arrangements; and the related livelihood and social issues. In exploring the potential of underutilised genetic resources the workshop was a contribution towards the 2030 Sustainable Development Goals.

The objectives of the workshop were to:

- Assess the current status of underutilised aquatic genetic resources at regional level and to assess R&D status of priority species with potential for use in food and agriculture.

- Discuss the knowledge gaps and way forward in defining regional priorities concerning underutilised aquatic genetic resources and create awareness on their potential role and value in diversification of food production and livelihood generation.

- Formulate strategies for strengthening the institutional framework for management of aquatic genetic resources and legal and policy frameworks to promote their conservation and sustainable use at the regional level.

The workshop provided a platform for sharing of knowledge and experience. Participants discussed the status of R&D in exploring underutilised aquatic genetic resources, conservation and sustainable use, development of commercial applications and benefits to rural communities. The possibility of establishing a regional network for knowledge sharing and other related issues at regional level was also considered.

NACA presented a discussion paper on information systems on fish and marine genetic resources, reviewing the objectives and status of public databases. Most databases can be broadly categorised as biodiversity and taxonomy oriented; geographic distribution and occurrence records; fisheries catch and effort; environmental monitoring and management; molecular genetics; or some combination of the above. In terms of data coverage and quality, excepting molecular genetics where data collection is rigorous and routine, most are patchy with records collected opportunistically due to the sheer magnitude of the task at hand. Existing systems are therefore of limited use in identifying underutilised genetic resources.

In the aquaculture context, looking at the existing public information systems, and noting the present low utilisation of genetically improved varieties, there is an apparent gap with regards to breeders registries, an issue identified at a Regional Expert Consultation on Genetically Responsible Aquaculture, organised by the ICAR-National Bureau of Fish Genetic Resources in India in February. An online federated system linking breeders registries could assist smaller hatcheries to participate in a large virtual broodstock population, assisting in genetic management and reduction of inbreeding while maintaining a high level of adaptive capacity.

The proceedings of the workshop will be published by APAARI in due course (www.apaari.org). NACA would like to thank APAARI for both the opportunity and financial support to participate in the workshop.

Joint Research Project on Utilization of Thailand Local Genetic Resources to Develop Novel Farmed Fish for Global Market

The Project for the “Unitization of Thailand Local Genetic Resources to Develop Novel Farmed Fish for Global Market” is a research project led by the Tokyo University of Marine Science and Technology and the Department of Fisheries, Thailand, with other notable research institutes in both Thailand and Japan.

The project will span five years from 2019-2024, supported by funding from the Japan International Cooperation Agency and the Japan Science and Technology Agency from the Science and Technology Research Partnership for Sustainable Development programme (STREPS). In order to share and promote the project, a kick off meeting was held on 26 July 2019 at the Centara Hotel, Central Ladprao, Bangkok. Participants were from project collaborators and representatives from other partners, with NACA attending in an observer capacity. There are a total of twelve project partners from Thailand and six from Japan.

The project is research-oriented and will address long overdue research and development needs such as the development of seabass and banana shrimp culture industries. Both species are native to Thailand and ASEAN nations and possess great culture potential.

The expected outputs of the project include:

- Development of molecular-supported breeding programmes for both seabass and banana shrimp.

- Development of preventative methods against infectious diseases in aquaculture, for both fish and shrimp.

- Development of new methods for production of high value added fish and shrimp, including nutrient enrichment methods, all-female populations and control of maturation methods for banana shrimp, and development of banana shrimp culture technology.

- Conservation of genetic diversity of native Thai species through establishment of a seed bank and development of germ cell preservation methods in fish and shrimp.

Impacts of climate change on fisheries and aquaculture

FAO has published a synthesis of current knowledge, adaptation and mitigation options. This is a must-read for all concerned with the aquaculture industry in any capacity. The abstract follows below. The publications is available for free download from:

http://www.fao.org/policy-support/resources/resources-details/en/c/1152846/

The 2015 Paris Climate Agreement recognizes the need for effective and progressive responses to the urgent threat of climate change, through mitigation and adaptation measures, while taking into account the particular vulnerabilities of food production systems. The inclusion of adaptation measures in the fisheries and aquaculture sector is currently hampered by a widespread lack of targeted analyses of the sector's vulnerabilities to climate change and associated risks, as well as the opportunities and responses available. This report provides the most up-to-date information on the disaggregated impacts of climate change for marine and inland fisheries, and aquaculture, in the context of poverty alleviation and the differential dependency of countries on fish and fishery resources. The work is based on model projections, data analyses, as well as national, regional and basin-scale expert assessments. The results indicate that climate change will lead to significant changes in the availability and trade of fish products, with potentially important geopolitical and economic consequences, especially for those countries most dependent on the sector.

In marine regions model projections suggest decreases in maximum catch potential in the world's exclusive economic zones of between 2.8 percent and 5.3 percent by 2050 according to greenhouse gas emission scenario RCP2.6, and between 7.0 percent and 12.1 percent according to greenhouse gas emission scenario RCP8.5, also by 2050. While at the global scale this average is not particularly large, the impacts are much greater at regional scale, because projected changes in catch potential vary substantially between regions. Although estimates are subject to significant variability, the biggest decreases can be expected in the tropics, mostly in the South Pacific regions. For the high latitude regions, catch potential is projected to increase, or show less of a decrease than in the tropics. It is important to note that these projections only reflect changes in the capacity of the oceans to produce fish, and do not consider the management decisions that may or may not be taken in response. It is concluded that the interaction between ecosystem changes and management responses is crucial to minimize the threats and maximize the opportunities emerging from climate change. Production changes are partly a result of expected shifts in the distribution of species, which are likely to cause conflicts between users, both within and between countries.

The vulnerability of marine fisheries to climate change and existing and potential responses to adapt to the changes are examined in more detail for 13 different marine regions covering a range of ecological, social and economic conditions. It is concluded that adaptations to climate change must be undertaken within the multifaceted context of fisheries, with any additional measures or actions to address climate change complementing overall governance for sustainable use. It is recognized that some of these measures will require institutional adaptation.

In relation to inland fisheries the Technical Paper highlights that in the competition for scarce water resources the valuable contributions of inland fisheries are frequently not recognized or undervalued. The Paper assesses country by country impacts and provides indications of whether levels of stress are expected to change and to what extent. Pakistan, Iraq, Morocco and Spain are highlighted as countries that are currently facing high stresses that are projected to become even higher in the future. Myanmar, Cambodia, the Congo, the Central African Republic and Colombia, are among the countries that were found to be under low stress at present and are projected to remain under low stress in the future. The implications of climate change for individuals, communities and countries will depend on their exposure, sensitivity and adaptive capacity, but in general they can be expected to be significant. Some positive impacts are also identified, like increased precipitation leading to the expansion and improved connectivity between some fish habitats, but to take advantage of them, new investments as well as flexibility in policies, laws and regulations, and post-harvest processes are needed. It is recommended that adaptive management measures be within the framework of an ecosystem approach to fisheries to maximize success.

Short-term climate change impacts on aquaculture can include losses of production and infrastructure arising from extreme events such as floods, increased risks of diseases, parasites and harmful algal blooms. Long-term impacts can include reduced availability of wild seed as well as reduced precipitation leading to increasing competition for freshwater. Viet Nam, Bangladesh, the Lao People's Democratic Republic and China were estimated to be the most vulnerable countries in Asia, with Belize, Honduras, Costa Rica and Ecuador the most vulnerable in the Americas, for freshwater aquaculture. Uganda, Nigeria and Egypt were found to be particularly vulnerable in Africa. In the case of brackish water production, Viet Nam, Egypt and Thailand emerged as having the highest vulnerabilities. For marine aquaculture, Norway and Chile were identified as being the most vulnerable, due to their high production, although China, Viet Nam, the Philippines and Madagascar were also considered to be highly vulnerable. Climate driven changes in temperature, precipitation, ocean acidification, incidence and extent of hypoxia and sea level rise, amongst others, are expected to have long-term impacts in the aquaculture sector at multiple scales. Options for adaptation and resilience building are offered, noting that interactions between aquaculture, fisheries and agriculture can either exacerbate the impacts or help create solutions for adaptation.

The Technical Paper also investigates the impacts of extreme events, as there is growing confidence that their number is on the increase in several regions, and is related to anthropogenic climate change. Climate-related disasters now account for more than 80 percent of all disaster events, with large social and economic impacts. Not all extreme events necessarily result in a disaster, and the extent of their impacts on fisheries and aquaculture will depend on how exposed and vulnerable the socio-ecological systems are as well as their capacity to respond.

An often unrecognized impact of climate change is on food safety, for example through changes in the growth rates of pathogenic marine bacteria, or on the incidence of parasites and food-borne viruses. Climate change may also bring increased risks for animal health, particularly in the rapidly growing aquaculture sector, for example by changing the occurrence and virulence of pathogens or the susceptibility of the organisms being cultured to pathogens and infections. Effective biosecurity plans that emphasize prevention are essential.

In the final sections the Technical Paper recognizes that the impacts of climate change on the fisheries and aquaculture sector will be determined by the sector's ability to adapt. Guidance on the tools and methods available to facilitate and strengthen such adaptation is provided. Because each specific fishery or fishery/aquaculture enterprise exists within unique contexts, climate change adaptations must start with a good understanding of a given fishery or aquaculture system and a reliable assessment of potential future climate change. The Paper provides information on the tools available to inform decision-makers of particular adaptation investments and of the process to develop and implement adaptation strategies. It presents examples of tools within three primary adaptation entries: institutional and management, those addressing livelihoods and, thirdly, measures intended to manage and mitigate risks and thereby strengthen resilience. It is noted that adaptation should be implemented as an ongoing and iterative process, equivalent in many respects to adaptive management in fisheries.

Finally, the contributions of the sector to global emissions of carbon dioxide are presented. Globally, fishing vessels (including inland vessels) emitted 172.3 million tonnes of CO_2 in 2012, about 0.5 percent of total global CO_2 emissions that year. For the aquaculture industry, it was estimated that 385 million tonnes of CO_2 equivalent (CO_2 e) was emitted in 2010, around 7 percent of those from agriculture. While the sector is a small contributor, options for reducing fuel use and greenhouse gas emissions are identified. In the case of capture fisheries, reductions of between 10 percent and 30 percent could be attained through use of efficient engines, larger propellers, as well as through improving vessel shapes or simply by reducing the mean speed of vessels. There are also opportunities to reduce greenhouse gas emissions in aquaculture, which include improved technologies to increase efficiency, use of renewable energy sources, and improving feed conversion rates, among others.

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The Technical Paper highlights the multifaceted and interconnected complexity of fisheries and aquaculture, through which direct and indirect impacts of climate change will materialize. Efforts to adapt to and mitigate climate change should be planned and implemented with full consideration of this complexity. Failure to do so would increase inefficiency and maladaptation, exacerbating rather than reducing impacts.

Finally, the Technical Paper is a reminder of the critical importance of fisheries and aquaculture for millions of people struggling to maintain reasonable livelihoods through the sector. These are the people who are most vulnerable to the impacts of climate change, and particular attention needs to be given to them while designing adaptation measures if the sector is to continue to contribute to meeting global goals of poverty reduction and food security.