Food and Agriculture Organization of the United Nations

International Collective in Support of Fishworkers

NFIFL/C1230 (En)

FAO
Fisheries and
Aquaculture Circular

ISSN 2070-6065

A REVIEW OF GOVERNANCE AND TENURE IN INLAND CAPTURE FISHERIES AND AQUACULTURE SYTEMS OF INDIA

Cover photograph: ©Nachiket Kelkar
A fisher on the Ganga River in Bihar

FAO Fisheries and Aquaculture Circular No. 1230 NFIFL/C1230(En)

A REVIEW OF GOVERNANCE AND TENURE IN INLAND CAPTURE FISHERIES AND AQUACULTURE SYSTEMS OF INDIA

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Published by
Food and Agriculture Organization of the United Nations (FAO)
and
International Collective in Support of Fishworkers (ICSF)
Chennai, 2022

Required citation:
Kelkar, N. & Arthur, R.I. 2022. *A review of governance and tenure in inland capture fisheries and aquaculture systems of India.* FAO Fisheries and Aquaculture Circular No. 1230. Chennai, FAO and ICSF. https://doi.org/10.4060/cb8615en

ISBN 978-92-5-135762-0 [FAO]

PREPARATION OF THIS DOCUMENT

This synopsis summarizes the diversity, complexity and relevance of tenure systems, rights and the institutional management and governance of inland fisheries in India, including inland capture fisheries, culture-based fisheries and aquaculture. An earlier draft served as a background document on the present governance and tenure landscape of inland capture fisheries and aquaculture in India for an International Collective in Support of Fishworkers (ICSF) workshop conducted in September 2019. The ICSF workshop was held at the Seva Kendra, Kolkata from 6 to 7 September 2019. The theme was 'Improving Inland Fisheries Governance in India.[1] It brought together fishery scientists, experts, activists, fishers and fishworkers, ecologists, and community development workers from as many as 17 regions across India on one platform. The workshop participants discussed the draft National Inland Fisheries and Aquaculture Policy (NIFAP) of the Government of India, 2018, in relation to FAO's Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines).

Simon Funge-Smith and John Valbo-Jørgensen at FAO commented on the paper, Robin Leslie edited the text and Romina Toscano formatted the document in line with FAO standards.

[1] The workshop recommendations can be downloaded and viewed here.

ABSTRACT

Key elements of tenure systems, rights and governance issues in the vast, diverse and complex inland fisheries of India are summarized. The objective is to highlight how inland fisheries have been changing and the associated challenges for governance and tenure. The legal and policy contexts, within which fishing in rivers, wetlands and estuaries takes place, are described as well as the diversity of fishing activities and practices in the different environments found in India, which include inland capture fisheries, culture-based fisheries and freshwater aquaculture systems. Multiple drivers of change that affect inland fisheries are discussed from within the fisheries sector and from wider social, economic and environmental contexts. The ways in which formal and informal institutional arrangements and customary access regimes interact with each other are highlighted. The potential outcomes of institutional change and emerging policies for ecological sustainability, economic equity and social justice are discussed, with a focus on capture fisheries within India's inland fisheries.

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ACKNOWLEDGEMENTS

We thank ICSF, Chennai, India, for providing the opportunity to compile this review paper and the Food and Agriculture Organization of the United Nations (FAO) for facilitating publication. Particular thanks to N. Venugopalan and Sebastian Mathew for their kind support, critical comments and guidance. Although this document was planned as a background paper to the workshop organized by ICSF in Kolkata in September 2019, feedback from the workshop has informed many of the sections. Sincere thanks also go to the ICSF team and staff for their support and organization of the workshop and to the fisheries scientists and experts, in particular, P.S. Ananthan, G. Chandra and V. Sugunan. We are grateful to Sushant Dey, Subhasis Dey, Vidyadhar Atkore, Kadambari Deshpande and Jagdish Krishnaswamy for contributing their photographs to this document. Finally, many thanks to the activists and fishers who shared their experiences at the workshop, especially the contingents from Odisha and Kerala, as well as all fishers and fishing groups in Bihar and the Gangetic Plains of India for their support.

ABBREVIATIONS AND ACRONYMS

CFR	Community Forest Resource Rights
CIBA	Centre for Inland Brackishwater Aquaculture
CIFA	Central Institute of Freshwater Aquaculture
CIFE	Central Institute of Fisheries Education
CIFRI	Central Inland Fisheries Research Institute
CIFT	Central Institute of Fisheries Technology
COFI	Committee on Fisheries, FAO
EAFm	ecosystem approach to fisheries management
FAO	Food and Agriculture Organization of the United Nations
FISHCOPFED	the National Federation of Fishers Cooperatives Ltd.
ICSF	International Collective in Support of Fishworkers
IMC	Indian major carps
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MUY	Matshyajibi Unnayana Yojana
NASO	National Aquaculture Sector Overview
NBFGR	National Bureau of Fish Genetic Resources
NFDB	National Fisheries Development Board
NFP	National Fisheries Policy
NIFAP	National Inland Fisheries and Aquaculture Policy
NPMF	National Policy on Marine Fisheries
NPSSF-I	National Platform for Small Scale Fish workers (Inland)
PMGKY	Pradhan Mantri Garib Kalyan Yojana
PMMSY	Pradhan Mantri Matsya Sampada Yojana
SC/ST	Scheduled Castes/Scheduled Tribes
SHG	self-help groups
SIFF	small indigenous freshwater fish
SOFIA	The State of World Fisheries and Aquaculture (FAO Series)

SOP	standard operating procedures
SSF Guidelines	Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication
TMS	Tawa Matsya Sangh (collective)

INTRODUCTION

INLAND CAPTURE FISHERIES IN INDIA WITHIN THE GLOBAL GOVERNANCE CONTEXT

Globally, inland capture fisheries are highly diversified and productive with commercial, subsistence, recreational and ornamental components. These fisheries take place in a wide range of environments from upland streams through rivers, floodplains and lakes, to river deltas and coastal lagoons and are found on every continent apart from Antarctica. Developing countries, mainly in Asia and Africa, produce around 90 percent of the reported global production (Funge-Smith, 2018), most of which is for local human consumption. Globally, inland capture fisheries production in 2018 was estimated to be over 12 million tonnes with a value of USD 17 billion (FAO, 2020). This represents about 11.3 percent of the first sale value of total global capture fisheries production (FAO, 2020; Funge-Smith, 2018). Inland aquaculture is also diverse in terms of species, culture practices and integration with other agricultural activities. Globally, the production of aquatic animals in 2018 was estimated to be 51.3 million tonnes, 91.5 percent of which was finfish (FAO, 2020).

Inland capture fisheries and aquaculture encompass a diverse range of ecosystem services. Crucially, they are a nutritious food source in many countries (where there are otherwise poor diets) to support livelihoods for millions of people, many of whom are socially marginalized and economically impoverished in several regions across the world (Cowx *et al.,* 2004; Smith *et al.,* 2005; Norman-Lopez and Innes, 2005; Gupta, 2006; Dugan *et al.,* 2010; Lynch *et al*., 2016b; McIntyre *et al*., 2016; Funge-Smith and Bennett, 2019). The importance of inland capture fisheries for rural nutrition, particularly in those countries with the highest per capita production, can be more significant than their economic value (Funge-Smith and Bennett, 2019). Despite their importance, compared to marine or coastal capture fisheries, inland fisheries tend to be overlooked in policy (Welcomme *et al*., 2010, Cooke *et al.*, 2016). For example, at the international level they are addressed in the Sustainable Development Goals (SDGs), as part of SDG 15.1 addressing inland aquatic ecosystems, the delivery of ecosystem services and sustainable use, as SDG14 has a focus on marine fisheries (Lynch *et al*., 2020). However, Funge-Smith (2018) has highlighted the important contributions that they can make across many of the SDGs. These include multiple roles in providing food, income and employment contributing towards poverty reduction (SDG 1), zero hunger (SDG 2) and good health and well-being (SDG 3). Additionally, inland fisheries and aquaculture can contribute to gender equality (SDG 5), responsible production and consumption (SDG 12) and potentially support action on climate change (SDG 13).

Globally, it is important to recognize that inland fisheries also face a range of threats that can compromise or undermine their role and contributions to livelihoods. Economic development, climate change and the impacts of anthropogenic degradation and fragmentation of inland waters (e.g. through flow regulation, dams and barrages, and pollution), intensification of fishing practices and conflicts over common-property resources all create significant challenges for the management of fishing rights and tenure (Marmulla, 2001; Tockner and Stanford, 2002; Ahmed, Andrew and John, 2006; de Graaf *et al*., 2015; Nguyen *et al*., 2016).

Inland capture fisheries and aquaculture production in India

Seven major rivers, together with their numerous tributaries, constitute the major river systems of India. These river basins, their floodplains and deltas support important inland fisheries and play vital roles in the livelihoods and culture of Indian people. India is the second largest global producer of inland fish from its freshwaters and brackishwaters (both capture- and aquaculture-based) after the People's Republic of China (FAO, 2020). According to the Central Inland Fisheries Research Institute (CIFRI), inland capture fisheries and aquaculture together produced almost 9 million tonnes, representing 75 percent of India's total annual fish production in 2019.[2] Most of this fish was locally or regionally consumed, contributing to the food security of millions of people directly and indirectly dependent on fishing and related activities (Rajeev,

[2] As described in the ICSF workshop report (ICSF, 2019).

2008; Welcomme, 2011; Lynch *et al*., 2016b; Funge-Smith and Bennett, 2019). India also has some inland recreational fisheries (Pinder and Raghavan, 2013), and there is increasing production of ornamental fish, mainly for export, originating both from capture and aquaculture production (Box 1).

Box 1. Ornamental fisheries

Native fish species used in the aquarium trade: Devario *sp. from India's Western Ghats*.

As well as providing important sources of fish for food, several environments also support important ornamental fisheries. Capture fisheries supplying ornamental fish species to the aquarium trade mainly target hill-streams along the Western Ghats, Central and Northeastern India and the Himalayan foothills and Terai river stretches (Raghavan *et al.,* 2007, 2013; Lakra *et al.,* 2010; Chakraborty, Shaw and Ghosh*,* 2017; Froese and Pauly, 2019).

Given that these fisheries are sometimes targeting endemic and threatened species, it is important to analyze the significance of this emerging industry both for rural incomes and for the preservation and restoration of endemic fish biodiversity. There may also be opportunities for captive breeding and even culture of these species as well as the culture of some exotic ornamental species (Raghavan *et al.,* 2007; Rani, Immanuel and Kumar*,* 2014). In terms of tenure, there has been some state licensing of ornamental fishers. However, much of the capture of, and trade in, wild specimens are not regulated, although restrictions and bans have been suggested, particularly for threatened species (Raghavan *et al.,* 2013, 2018).

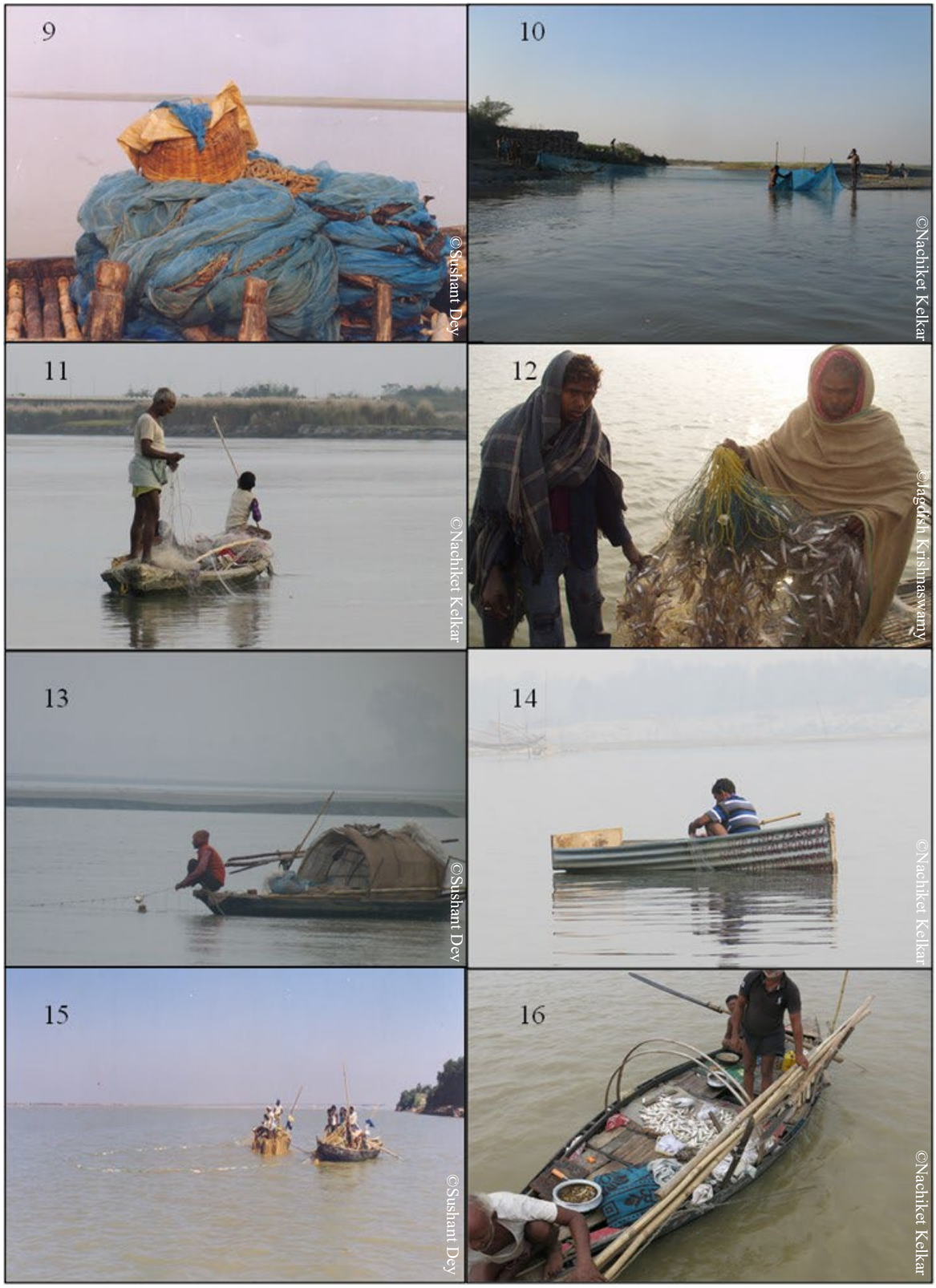
Stocking, or fisheries enhancement measures, are also a common feature of inland fisheries. They include use of wild seed and fry (capture-based aquaculture) or use of hatchery-produced seed and fry (culture-based fisheries) to supplement naturally occurring wild stocks. Alternatively, the emphasis is on the stocked fish in pond or cage aquaculture systems that can range in size from small-scale household production to large industrial systems incorporating fish farms and hatcheries. As such, inland fisheries across India can be broadly categorized as capture fisheries, culture-based fisheries and freshwater aquaculture. In some brackishwater areas, production can alternate between capture-based aquaculture and culture-based fisheries over the course of the year.

In contrast to culture systems, capture fisheries occur predominantly in rivers, streams and wetlands and are based on the harvesting of wild fish. They are dependent on natural productivity and frequently demonstrate seasonal and interannual variability, both associated with hydroclimatic fluctuations related to monsoonal rainfall and/or glacial precipitation, seasonal flood pulses, freshwater–saline mixing processes, temperature variability and land surface–hydrology interactions (Das *et al*., 2012; Kelkar, 2014a; Dudgeon, 2000; Payne *et al*., 2004; Arthington *et al*., 2006).

Inland capture fisheries and aquaculture in India occur within a wide range of aquatic environments including both open waters (e.g. flowing rivers, canals) and enclosed (e.g. lakes, ponds and reservoirs) or semi-enclosed (e.g. wetlands) waterbodies (Welcomme, 2001; Welcomme *et al.*, 2010). These environments include perennial and seasonal rivers, and in upland areas may include streams, reservoirs and cold-water lakes. Lowland environments include floodplain wetlands (*inter alia* oxbow lakes,

beels, *khaals*, *mouns* and *haors*), natural and human-made lakes (tanks), dug-out ponds, reservoirs and irrigation canals. Seasonal ponds and *nullahs* may also be key features. Finally, there are estuaries and brackishwater lakes (Sinha, Khan and Jha, 1999; Welcomme, 1995; Welcomme, 2001; Kumar, Joshi and Katiha, 2003, Vinci *et al*., 2003; Jha, 2009). This diversity of environments creates a range of habitats. They are home to over 900 fish and invertebrate species (e.g. shrimp, prawns and crabs) that support inland fisheries (Froese and Pauly, 2019; Payne *et al*., 2004). Traditional fishing activities within these environments involve multiple ecologically-tuned skills and local knowledge accrued from experience and traditions (Santha, 2008a,b; Santha, 2010; Deb and Haque, 2014). This is evident from the wide range of fisheries technologies and fishing practices (Box 2).

Box 2. Inland fisheries technologies in north and east India



Capture fisheries involve a range of passive and active fishing gears and nets: traps and stake nets (1-4), trammel nets (5), crab traps (6), drag nets (7), cast nets (8), mosquito nets (9,10), small and large gillnets (11,12), hook lines (13), current nets for hilsa (14), seine nets (15) and fishing with the use of fish or dolphin oil as bait (16).

Inland fisheries in India range from small-scale subsistence to commercial capture fisheries. A wide range of active and passive gears are used for fishing both from the shore and from boats, canoes and coracles (see Box 2).

The gears used reflect the culture and knowledge of the fishers of India. Fishers use a wide range of active and static fishing gears in different ways (Box 2). The specific gear used relates to a range of factors including the nature of the fishery environment, target species, habitat and season. Other factors may be socio-economic and relate to the types of gears that are permitted, or access to financing and credit.

Some gears can be used by individuals while other larger gears, including seine nets, may require teams of fishers to operate them. There are also some gender differences in gear use, for example scoop nets may be used predominantly by women while other gears may be associated with children. Many fishing gears have been developed to reflect the behaviours of the target species, including habitat use, migration, feeding and spawning based on fisher knowledge that has evolved over many years. Fishing gears may be used to target fish and other aquatic organisms at all stages of their life cycles and there are several fisheries that target juveniles and larvae, often using fine mesh nets, for use in capture-based aquaculture.

Materials used for fishing gears include traditional materials, such as bamboo that is used for traps and lift net frames and more modern materials such as monofilament gillnets and fishing lines. To enhance the effectiveness of the gear and to increase the efficiency of fishing activities, fishers may also modify the habitat to aggregate fish (Figure 1).

Figure 1. Vegetation is accumulated in floating masses to aggregate fish species for capture. This is a *pala ghera* fishing spot in a wetland of West Bengal's Durgapur area

While capture fisheries are widespread and make important contributions to livelihoods, state and national governments have emphasized the development of culture-based fisheries and aquaculture. Allied to the widespread use of lease-based tenure, these practices have become widespread. In West Bengal, culture-based production of major carps was intensified to integrate biological sewage treatment in ponds and tanks with fish production (Pant and Verma, 2010). In Andhra Pradesh, expansion of freshwater aquaculture throughout the 1980s was largely conducted via cooperative integrated farming schemes, which made the state a national leader in terms of total carp and non-carp fish production (Belton *et al*., 2016). Culture-based fisheries, often based on the stocking of Indian major carps, are most common in floodplain and agricultural wetlands, reservoirs, *beels*, tanks and ponds (Vinci *et al*., 2003) with harvest and management formats changing with levels of stocking, allocations of rights and enhancement plans (Kumar, Joshi and Katiha, 2003). These fisheries produce a mix of stocked and wild fish. Freshwater aquaculture involves more intensive intervention in the life cycle and includes extensive, semi-intensive and intensive aquaculture

systems (Oddsson, 2020). Freshwater aquaculture tends to be productive, yielding and utilizing significant biotechnological and energy inputs for overcoming natural constraints on fish yields (Pillai and Katiha, 2004; Katiha *et al*., 2005).

Total freshwater fish production varies across the states and union territories of India. States such as Andhra Pradesh (2.8 million tonnes) and West Bengal (1.6 million tonnes) are highly productive, contributing 32 percent and 17 percent of total freshwater fish production. Other states, e.g. Uttar Pradesh (0.6 million tonnes), Odisha (0.5 million tonnes) and Assam (3.27 million tonnes) also make significant contributions (Government of India, 2019a). There are also states with fewer water resources, such as Rajasthan and Himachal Pradesh where the contribution to freshwater fish production is much lower. Ainsworth, Cowx and Funge-Smith (2021) estimated that West Bengal, Bihar, Assam, Odisha, Andhra Pradesh and Uttar Pradesh might account for over 75 percent to 80 percent of the total wild fish catch. They also concluded that there is a need to disaggregate the data to be able to fully understand the contributions of inland capture fisheries.

However, it is freshwater aquaculture and culture-based fisheries that dominate the total production from India's freshwater fisheries, with revenues estimated to account for nearly 95 percent of India's total culture fish production (Kumar, Joshi and Katiha, 2003; Katiha *et al*., 2005; NASO-India, 2014). Andhra Pradesh, West Bengal, Odisha, Assam, Telangana and Maharashtra are the major states that practise freshwater aquaculture and culture-based fish production (Belton *et al*., 2016; Kummari *et al.,* 2018). Production is largely based on the Indian major carps, namely catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*). The freshwater and brackishwater aquaculture sectors also involve farming of freshwater prawn and brackishwater shrimp and non-carp finfish (e.g. catfish, tilapia, mullets). The demand for major carps is the highest across freshwater and marine fish groups (Kumar *et al*. 2005).

Integrated and composite systems are an important feature of farming landscapes throughout the country that can support productive fisheries (Jha *et al*., 1991; Jha, 1995; Jha, 2009; Vinci *et al*., 2003). Fish can be incorporated in the production of commercially important crops including rice and aquatic plants (Jha, 2009). Fish are also incorporated into livestock–fish systems, for example where chicken coops are placed over fish ponds. The relative importance of the different systems is difficult to determine as inland fishery statistics are not disaggregated by production sources, obscuring the relative contributions of capture, aquaculture and culture-based fisheries.

Socio-economic, livelihood and nutritional importance of inland fisheries in India

The Government of India estimates that around 23 million people across the country depend on inland and marine fisheries (Government of India, 2021). Overall, the figure is still likely to be a significant underestimate (Fluet-Chouinard, Funge-Smith and McIntyre, 2018) but the estimation of dependence remains difficult. Census figures used to calculate numbers of fishers are typically based on fishers who proclaim to belong to 'traditional fishing castes', rather than on their present dependence or activity in capture fisheries.

As noted by Jassal (2001), fishing castes are often loosely defined by fishers and include a wide range of ethnic groups and communities involved in fishing. Furthermore, inland capture fisheries and aquaculture can be represented among a 'portfolio' of livelihood activities. Seasonally or interannually, the same people may or may not be actively fishing (Santha, 2010). This, together with the spatially dispersed nature of inland capture fisheries and aquaculture also makes it challenging to estimate overall population dependence. It is accepted that inland fisheries make important contributions and that there is potential to increase freshwater fish production in India through aquaculture and culture-based fisheries. At the same time, it is also acknowledged that inland fisheries have yet to receive due recognition at state and national levels (Government of India, 2011; Kumar, Joshi and Katiha, 2003; Sharma *et al*., 2013).

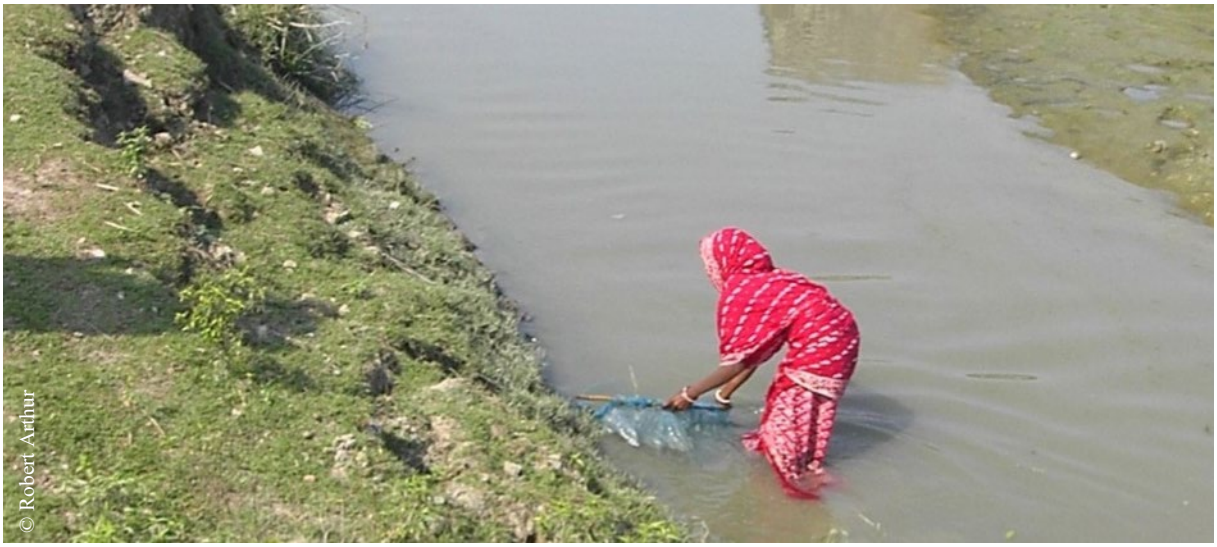
Determining who can benefit from activities associated with inland fisheries and aquaculture, for how long and under what conditions depends on the tenure arrangements. The governance of tenure is therefore a crucial element in realizing the important livelihood benefits inland fisheries can provide. A key challenge

is that inland capture fisheries globally suffer from insecure tenure arrangements. Tenure arrangements may be informal or customary in nature, often with no legal codification or state recognition (Hodgson, 2016; FAO, 2020) or there may be a combination of state regulations and local customary rules (Bavinck, 2003).

Box 3. The gender dimension of inland fisheries

Twenty-eight percent and 40 percent of India's fishers are estimated to be women and children, respectively (Government of India, 2018a). While it is a common assumption that men catch while women process and sell fish, in many cases women also regularly catch fish and collect crabs, prawns and prawn seed (Mitra *et al.,* 2017). Women also play important roles in culture-based fisheries and aquaculture, contributing to pond management and assisting with the capture and marketing of fish (Kumar, 2010; Kumar and Talluri, 2016). In aquaculture cooperatives, greater participation of women has also helped to reduce conflicts over access rights (Jassal, 2003).

Given that women are often constrained by family roles and related social networks, they tend to have less ability to become involved in collective groups and gain credit. As a result, more accessible, marginal inland waterbodies, such as rice-fields, ditches and streams can often represent important fishing environments for women.



A woman collects small fish from a shallow channel

Trends towards lease systems and culture-based fisheries mean that it may be more difficult for women to maintain or enhance their roles in fisheries. Women also voice concerns about the fisheries and the way that they are managed, for example, regularly expressing worries about education, health, social welfare and the future of their children, with most saying that they do not want their children to become fishers (Kelkar, 2014a).

Institutional and policy context for Indian inland fisheries

Unlike marine capture fisheries, where management is a shared responsibility between central and state governments, aquaculture and inland capture and culture-based fisheries are 'state subjects', meaning that the legislation and policies to govern them vary from state to state, and that responsibility for management lies with the state governments (Sharma *et al*., 2013). Existing state legislation generally vests the ownership, and hence revenue rights, to inland waters with the respective state fisheries departments (Datta, 2014). While state laws and policies share many common features, there are also important divergences that reflect the different local contexts within which inland fisheries operate (Kumar, Joshi and Katiha, 2003). There are also wider policies that are also relevant to inland fisheries. For example, the Protection of Human

Rights Act (1993) includes rights to life, liberty, equality and dignity. These rights, guaranteed by the Constitution of India and embodied in international covenants, are inseparable from fishing rights. First and foremost is the recognition of the "minimal right to water", which is also recognized in the draft NFP (2020) and relates to access rights of members of local fishing communities.

Management of inland fisheries is supported by several scientific organizations under the Indian Council of Agricultural Research that address different facets of inland capture fisheries and freshwater aquaculture management. The Central Inland Fisheries Research Institute (CIFRI) located in Barrackpore, West Bengal, is the lead scientific institution that deals with research and development of inland fisheries. Others include the Central Institute for Fisheries Education (CIFE), the Centre for Inland Brackishwater Aquaculture (CIBA), the Central Institute of Fisheries Technology (CIFT), the Central Institute of Freshwater Aquaculture (CIFA), the National Bureau of Fish Genetic Resources (NBFGR), the National Fisheries Development Board (NFDB) and the Directorate of Coldwater Fisheries. Typically, these organizations work through collaborations and knowledge partnerships.

As with inland fisheries policies in other parts of the world (Bush, 2008), the focus of both state policies and the mandates of associated scientific organizations over the past five decades have been dominated by an agenda of freshwater aquaculture growth. Aquaculture and culture-based fisheries are perceived as modern production-based solutions to boosting income and food security and are valued for their promise of high revenues, yields and contribution to large-scale food security (Katiha *et al*., 2005; Bagchi and Jha, 2011). Throughout South Asia, this focus has resulted in freshwater aquaculture aggregate revenue and yields have grown exponentially (Belton, van Asseldonk and Thilsted, 2014). In contrast, inland capture fisheries tend to be neglected. While their importance is recognized along with the key contributions that they make to the livelihoods of the rural poor across India, there appears to be a reluctance to address complex management challenges and there remains greater interest in the technological solutions offered by aquaculture (Ahmed, 1997; Dey *et al*., 2008; Karki *et al*., 2018).

The need for a review

Inland capture fisheries and aquaculture in India are widely variable and heterogeneous in terms of the types of geographic regions, waterbodies and fish species they cover, the diversity of tenure arrangements, cultural practices and techniques and technologies involved, and, most importantly, the historical and present institutional structures that govern them. As described earlier, the socio-economic, legal, cultural and ecological pluralities of inland fisheries in India intersect and interact in complex ways. A key goal of tenure governance is to improve food security and/or livelihoods and the contributions towards human well-being, with an emphasis on vulnerable and marginalized people. As such, the protection of tenure and access rights of inland fisheries is a critical contribution. Given the frequently informal nature of many arrangements and the interest in developing inland fisheries, it is important to explore the role of tenure in inland fisheries governance. This is especially pertinent where there may be implications for dependent people regarding changes in tenure arrangements that may result from drivers such as economic development.

The primary objective of this review therefore is to provide a description of the existing tenure rights and associated institutional arrangements in India's inland fisheries (including culture-based fisheries and freshwater aquaculture), with identification of contextual realities that can constrain or enable the realization of fishing rights and access. To address this requires examining the social realities of India's waterscapes, including the roles of the numerous caste-groups across the country who identify fishing as their traditional occupation (Jassal, 2001; Doron, 2013, 2016; Kelkar, 2018) and the historical (and specifically, colonial) legacies of private or state control that still influence institutional arrangements and laws (Upadhyay, 2009). Inland fisheries thus include a wide range of actors, practices, power relations and historical conflicts (Sneddon *et al*., 2002; Santha, 2009; Robbins, 2012). The first step towards improving the governance of inland fisheries, especially capture fisheries, is to understand these aspects across different systems. Issues of fishing rights and access, which are central to the governance of tenure in inland capture fisheries, need to be studied with this understanding (Allison *et al*., 2012; Basurto, Gelcich and Ostrom, 2013; ICSF, 2014).

The review briefly introduces the concept of tenure as it applies to fisheries before moving on to describe the key historical trends in the governance of inland capture fisheries in India during the colonial period, under British administration, and after Independence. Further, it highlights some of the implications of current institutional arrangements and capacities to sustain fishing rights and access, in managing inland capture fisheries, in relation to the governance of tenure and individual or community entitlements.

The review then describes tenure arrangements and drivers of change in different fishing environments in India, highlighting the diverse nature of inland fisheries. It further focuses on identifying the types of rights that are held by different actors, including the state, groups and individuals, before expanding on the types of drivers of change and the effects that they are having on inland fisheries and benefits derived from them.

The review concludes with a discussion on the ways that inland fisheries in India are being transformed, and the institutional, policy and technological aspects that underpin this, before concluding with reflections on what this might mean for tenure and rights in the context of international policy instruments related to tenure and small-scale fisheries. In doing so it highlights the importance of rights associated with socio-economic development, opportunities for democratic participation in decision-making, labour and gender issues, and environmental conservation in tandem with the management and access rights to inland capture fisheries and aquaculture (FAO, 2012, 2013a,b, 2014, 2017; Lentisco and Lee, 2015).

ACCESS AND TENURE IN INLAND FISHERIES

Tenure essentially represents the relationship among people with respect to land and other natural resources. The rules of tenure determine who may benefit from natural resources (land, forests, fisheries and so forth), for how long and under what conditions (FAO, 2012; Kitolelei *et al*., 2019). Following the Global Forum on rights-based approaches for fisheries (FAO, 2016), this is also recognized to mean not only those who are fishing, but also includes the entire spectrum of beneficiaries. Tenure can be considered as comprising 'bundles' of various interconnected rights in relation to fish resources. Claims to rights can extend beyond the fish resources and include water use and sand mining as well as participation in decision-making and rights to information (NPSSFI, 2019a,b). For example, in Uttar Pradesh some fishers have claimed the right to mine sand from the rivers as part of a bundle of rights related to their livelihoods that includes fishing.

The nature of the bundle of rights held can determine the ways in which the individual or groups can benefit from the resource, and these rights may also be accompanied by particular capacities. Therefore, in this review tenure is considered as the period during which groups or individuals have a legitimate set of capacities to benefit from the fishery (Ribot and Peluso, 2003; Leach, Mearns and Scoones, 1999). Attention is also paid to the factors that can enable or constrain their ability to do so. For example, an individual may be allowed to fish but may not have the necessary gear, or societal norms and customs (e.g. related to caste or gender) may prevent the person from engaging in fishing or handling fish.

Even where individuals harvest fish, they may not have the ability to solely determine what is done with the harvest. This highlights that there can also be institutions (i.e. rules and social norms) and factors independent of fisheries management that affect the ability to benefit from the fishery (Box 4). For example, in India tenure rights in capture and culture-based fisheries also include access to roads leading to waterbodies and riverbank areas for anchoring boats and landing fish catches. According to the Indian Easements (or Encasements) Act, 1882,[3] such rights can be granted to fishers as 'easements' or even prevented by the owners of the land or adjacent estates in question.

From a practical point of view, it is useful to distinguish access and management as two different yet often overlapping bundles of rights as they may benefit different groups or people (Box 4). Firstly, *access rights* represent the right to fish and enable individuals and groups to benefit from fishing and associated activities. Secondly, *management rights* are rights to manage the fishery, making decisions about who may have access rights and on what conditions. Management rights are important as they can also create opportunities for management rights holders to benefit from the resource, albeit often indirectly.

Box 4. Institutions, access and the ability to benefit

Much of the focus on issues of access and rights in fisheries concerns institutional arrangements, with an emphasis on property rights and the conditions that can facilitate the design and implementation of enduring institutions. However, inland capture fisheries are located within dynamic aquatic landscapes and the institutional arrangements that have developed are the result of historical processes of negotiation and contestation over what people can do and what benefits they can derive.

Rather than focusing on property rights, Ribot and Peluso's (2003) theory of access presents access as a 'the ability to benefit' that is derived from the bundles of rights that, in turn, enable people, individually and collectively to benefit from natural resources, including fisheries. This approach to access is useful when considering traditional, customary and informal institutions, which are common in inland fisheries at the local level, that may not emphasize property rights. Indeed, a regular feature of customary arrangements is that individuals are often subject to constraints to enable a wider range of people to be able to benefit from the fishery.

[3] The Act has been a matter of numerous cases regarding fishing-related rights (e.g. Sreedharan vs Madanan, Kerala High Court, 3 December 2002, 2003 (1) KLT 320).

In addition to the benefits provided by these rights, it is important to consider the social and environmental costs of complying. Analysing tenure arrangements from the perspective of the nature and distribution of benefits and their contribution to poverty reduction underscores the importance of taking the analysis beyond the relationship among the fisher, the natural environment and regulatory body to include aspects such as gender, caste and local traditions (Ribot and Peluso, 2003). Such an access framework that extends beyond property rights incorporates the social, cultural and economic factors that could constrain or enable fishers to benefit from the use of fishery resources. A combined analysis of rights and access based on this way of describing tenure helps to evaluate institutional dynamics related to fishing access and management rights and tenure as well as the nature and distribution of benefits derived from these resources.

EVOLUTION OF TENURE GOVERNANCE IN INDIAN INLAND FISHERIES

India is a federal republic, subdivided into 28 states and eight union territories. According to the Constitution, the state legislatures are responsible for making laws and regulations with respect to relevant areas including water supplies and storage, irrigation, land tenure and fisheries. State control of inland fisheries in India (such as rents, royalties, grants, taxes, spatial restrictions, bans and prohibitions, species restrictions) has a long history (estimated from the third century BCE onwards), even though the forms of control and their political and economic underpinnings varied (Sharma, 1983; Khan, 1985; Agarwal, 2007; Reeves, 2003; Sen, 2015). The focus of control was capture fisheries in rivers, floodplain wetlands, estuaries and other open waters, although culture-based fisheries were also a feature of enclosed waterbodies such as tanks and ponds (Agarwal, 2007). In addition to the state seeking to extend its management rights through restrictions, there were also local arrangements to secure access rights to fishing areas through customary forms of tenure (Sen, 2015: Reeves, 1995: Reeves, 2002).

With the East India Company controlling revenue extraction from the eighteenth century onwards, systematic, intensive and consolidated regimes of private ownership of riparian land undermined the pre-existing informal and customary arrangements across India (D'Souza, 2004; D'Souza 2006; Singh, 2008: Lahiri-Dutt and Samanta, 2013; Singh and Gupta, 2018). Arrangements such as the Permanent Settlement of Bengal were created during the colonial rule in terms of land tenancy and private landed property (Guha, 1963; Lahiri-Dutt, 2014). These arrangements differed across regions in their capacity for rent extraction (Reeves, 1995; Reeves, 2002; Pokrant, Reeves and McGuire, 1997: Pokrant, Reeves and McGuire, 2004). This focus on landed revenue led to oppression and imposition of high rents on rural farmers and peasants by the powerful landowning or *Zamindar* classes, for example in Bengal (Hill, 1997). With the Permanent Settlement of Bengal and consolidation of freehold private land tenure, fisheries assets (called *jalkars* in Bengali) – mainly consisting of floodplain wetlands, channel inlets and river stretches – were also attached to large land estates (Reeves, 1995).

Even after the transfer of power to the British imperial administration from the mid-nineteenth century, riparianism (based on European and American laws for private riparian rights or public rights) remained the main guiding legal principle for granting fishing rights (Reeves, 1995; Puthucherril, 2009). As a result, management and access rights to inland capture fisheries were maintained as subservient to land ownership (D'Souza, 2006). The effect was also to draw hard boundaries to private control over water, including riparian zones, and the 'alluvion and diluvion' of massively flooding rivers or flowing waters (e.g. paleo-channels) and other hydrologically connected wetlands (Doss, 1891; Ghose, 1930). The legal complexities of colonial rule generated regimes of uncertainty, which triggered several contested interpretations of fishery laws, and ultimately led to the erosion of communal rights and customary tenure in many regional capture fisheries (Blomley, 2008; Sen, 2015; Bhattacharya, 2018). By the end of the nineteenth century the British administration had brought about a legal transformation of earlier local and informal fisheries tenure arrangements.

In line with the dominant economic policies of British India, the major focus of those holding the management rights to the fisheries through riparian landholdings was to generate revenues through the leasing of access rights (Box 5, Box 6). These arrangements created regular and continued conflicts among different fishing groups based on their differing ability and capacity to bargain for fishing rights through the payment of rents to landed estates (Nakazato, 1994; Lahiri, 1940). There were cases however where estates would grant fishing rights during the flooding season, when waterbodies became connected and the boundaries of the areas under private ownership could not be clearly distinguished (Reeves, 1995; Barman, 2008). The revenue systems associated with the new tenure arrangements also varied across different provinces of India. In Bengal, the *Zamindari* system of revenue collection dominated the relations of production. In regions such as the Punjab, Assam and the provinces and princely states in northern British India, *Mahalwari* systems were introduced (based on co-sharing arrangements for land revenue generation and settlement), while in the southern parts, *Raiyatwari* land settlement and revenue collection systems (directly from cultivator peasants) were implemented. It has been shown that regions with the latter two

systems fared better than the *Zamindari*-controlled regions in independent India in terms of agricultural investment and returns (Banerjee and Iyer, 2002).

Box 5. Leasing terms, periods and conditions

Given the history and emergence of lease systems as a common form of tenure arrangement in inland capture and culture-based fisheries, it is interesting to consider fishers' perspectives on the terms and lease periods.

In practice these vary considerably across states. In some areas where the leases are held by commercial operators the preference can be for longer leases to provide additional opportunities to generate income. In the Hindi-speaking states across Northern India, fishers often perceive that obtaining spatially bounded and short-term leases provides an easier and more affordable way of securing tenure (Kelkar, 2014b). These rights also typically restrict the fisher to catching specific species or sizes of fish or using particular fishing gears.

The leasing system provides a means to transfer access rights. It can also involve the transfer of some management rights, for example exclusion and the right to stock the waterbody. In other cases it may also involve transfer of the responsibility to allow subsistence fishing by local people.

These economic and legal transformations, especially of fishery 'commons', juxtaposed the vast hydrological transformation of India's rivers under colonial rule (D'Souza 2006). Diversion of river waters by dams, embankments and canals led to declines in fish yields from the 1850s onwards (Iqbal, 2010). The British administration recognized these declines but opted to blame overfishing by local fishers. Underlying this perception was a general idea that the supposedly wasteful and ignorant fishing practices of fishers needed control and regulation. Notions of scarcity influenced the intensity of state control and regulation through the colonial and postcolonial periods (see D'Souza, 2019). Francis Day, the first Inspector-General of Fisheries of British India, recommended numerous restrictions and regulations on fishing, including minimum mesh sizes, closed seasons, policing and the control of animals that eat fish (Day, 1873). Day's report set the tone and language of the fishery laws that were to follow.

Box 6. Key actors associated with Indian inland fisheries

The dominant form of allocating access rights is through systems of licences and leasing, the latter where contracts are given to bidders. These are often not open to all and, instead, are frequently based on specific membership criteria, often related to being recognized as a fisher or fish worker. Thus traditional fishers and fishing castes are important actors. However, fishers' associations and cooperatives may also be used by commercial interests to gain access rights, and these actors may also be attractive to the leaser as they can potentially get a better lease price.

In recent years, there has been a move by many states to mandatorily vest leasing rights with the state fisheries departments (e.g. Bihar), increasing lease periods up to ten years (e.g. Assam), reducing ad hoc procedures of contracting in inland fisheries (e.g. Maharashtra and Madhya Pradesh), and the clear differentiation of ownership rights and management rights, especially in the case of culture-based fisheries in large reservoirs.

The current situation therefore is one where state agencies, private interests and cooperatives are the major formal stakeholders in inland capture fisheries and freshwater aquaculture. For example, in Assam, where the management of capture and culture-based fisheries lies with diverse agencies and stakeholders, including government departments, private bidders, cooperatives, and local fishery committees for rivers, *beels*, tanks and ponds (Sugunan and Bhattacharjya, 2000; Chandra, 2007, 2011). However, state departments other than those charged with fisheries also need to have formalized laws to protect fish in open waterbodies managed by them.

The passage of the Indian Fisheries Act[4] was followed by private fisheries Acts across different British India provinces and these Acts uncritically included Day's recommendations (Southwell, 1915). Fishery cooperatives were instituted in many Indian provinces by the 1920s, but their functioning and evolution varied according to the intensity of pre-existing private and even state control on fishing rights and practice. In the early twentieth century, some recognition of 'public rights to fish' by the British administration began. However, its translation to fisheries on most rivers remained difficult (Gupta, 1908) and struggles over access and tenure led to the emergence of different arrangements across regions. These included various common property regimes, leasing systems based on auctions, licences and permits as well as state takeover of previously private capture fisheries (e.g. Chandra, 2011; Sen, 2015). Throughout this process, the scope for realizing individual or community management rights has remained limited.

A growing trend identified by Kumar *et al*. (2018) has been to allow limited access and cooperative-based management of river stretches for capture fisheries and small-scale culture or enhancement through the formation of village fishing committees (e.g. in Bihar), instead of granting leases to private contractors and entrepreneurs. Some states also give legal recognition to customary subsistence fishing rights (but not culture rights) in a number of state-owned or privately-owned waterbodies, whereby fishers can apply for partial or short-term leases based on the public trust doctrine (Kumar, Joshi and Katiha, 2003). How this recognition translates to legally secure rights is not well defined. Along the Brahmaputra River and wetlands (*beels*) in Assam, Chandra (2011) described how different management regimes can have overlapping arrangements for obtaining rights. As a result, the diverse actors involved with multiple fisheries management regimes must negotiate their respective roles to realize rights and benefits (Sinha and Katiha, 2002; Chandra and Bhattacharya, 2016). In such cases, there can be trade-offs between securing and formalizing access rights, and more flexibility and ability to meet individual needs under customary arrangements despite the less secure individual tenure they represent (Katiha, Sharma and Chandra, 2013). There are also examples of unregulated capture fisheries that are characterized by conflicts over access rights between local and interstate and intrastate migrant fishers, examples of which are common in the Gangetic Plains along the shared borders of Bihar, Jharkhand and West Bengal.

[4] The Indian Fisheries Act was repealed in 2015, but the basic tenets of its restrictions have persisted in most state-level fishery laws.

RECENTLY DRAFTED NATIONAL FISHERIES POLICIES: A BRIEF OVERVIEW OF THEIR RELEVANCE

The evolution of tenure arrangements has resulted in fisheries with a strongly local and regional character in terms of definitions, rights and related governance arrangements. State regulation of inland fisheries varies from place to place. Common features include bans on the fishing of juvenile fish and breeding adults (with exceptions in some states), closed fishing seasons in the monsoon, bans on fishing with dynamite and poisons, protection of the interests of traditional fishers, preference to primary fishers' cooperative societies and allocation of fishing rights in large waterbodies by local self-governments. The main divergences relate to lease periods for capture and culture-based fisheries in tanks and ponds, different methods for establishing lease values, different definitions of 'fishers' and different rules on effort and the ownership of wetland and river floodplain capture fisheries.

Different interpretations of state-level or local rights have created challenges in implementing legislation and providing effective governance. Given the diversity of fisheries policies at the state level, policy-makers have therefore come to regard the lack of a national-level policy framework for inland fisheries as an important issue. Policies being developed at the national level are beginning to address some of these concerns by providing guidance to states and union territories. During 2018 and 2019, the Ministry of Agriculture and Farmers' Welfare, Government of India, sought to develop an overarching framework to provide guidelines on developing legislation and policy, in the form of a National Inland Fisheries and Aquaculture Policy (NIFAP). This followed the National Policy on Marine Fisheries (NPMF) of 2017 and attempted to align its objectives with the NPMF's seven pillars of management, namely, sustainable development, socio-economic upliftment of fishers, principle of subsidiarity, partnership, intergenerational equity, gender justice and a precautionary approach.

Draft National Inland Fisheries and Aquaculture Policy (NIFAP), 2018

India's 2018 draft NIFAP identified and prioritized the sustainable management and governance of inland fisheries in India (Government of India, 2019b). The vision of the policy was of "ecologically healthy, economically viable and socially inclusive inland fisheries and aquaculture that generates gainful employment and economic prosperity". The NIFAP's broad objectives pertained to the optimal utilization and sustainable management of inland capture fisheries and aquaculture resources. This would be achieved by applying an ecosystem-based approach to fisheries management, increasing fish production and fishers' living standards, creating gainful employment and marketing opportunities, and ensuring food security while conserving native fish genetic stocks and associated ecosystem services from fisheries. Katiha *et al*. (2017) reported in a study of six states, that the socio-economic indices of inland fishing households and communities were limited to only 50 percent, approximately, of the desired levels. Thus, economic development through direct market benefits and incomes for capture and culture-based fishers was a major target of the NIFAP.

Following a comprehensive consultation process with multiple stakeholders, a committee of experts on inland fisheries drafted the NIFAP. In deliberations and discussions on the draft NIFAP[5], inland fishery stakeholders had made many recommendations towards expanding the scope of the NIFAP to include issues concerning tenure (NPSSFI-2019a,b). Other recommendations emphasized the need for a greater acknowledgement of conflicts concerning tenure arrangements. It was also suggested that the NIFAP should engage more with the political economy underlying tenure, and with the complexities of and conflicts over legal recognition of rights for fishers identified as 'traditional' based on informal, fluid and socioculturally assumed criteria (Kelkar, 2019).

The NIFAP's guidelines on development practices were drafted to align with the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines - FAO, 2014). The thirty-first session of the Committee on Fisheries (COFI) endorsed the SSF Guidelines in June 2014 to recognize the importance of a human-rights-based approach in fisheries

[5] For example, in the ICSF workshop (ICSF, 2019).

governance and management (Allison, 2011; Charles, 2011; Allison *et al*., 2012; Ratner, Åsgård and Allison, 2014; FAO, 2017). Importantly, the NIFAP had been envisaged as an evolving instrument open to periodic review based on continued feedback on needs and priorities. The NIFAP advocated an Ecosystem Approach to Fisheries management (EAFm) across freshwater, brackishwater and landlocked saline areas across India. It recognized significant scope for utilizing the potential of inland waters for commercially viable fish production. It also incorporated a wide range of issues including the development of marketing, postharvest activities, trade, gender equity, institutional governance and participation, public–private and community partnerships. The guidelines highlighted the need to adopt inclusive approaches in the fisheries sector and to support the holistic development of fishing communities, especially in relation to small-scale fisheries management and development. The consensus principles from the SSF Guidelines and the guidance on addressing small-scale fisheries were intended to inform planning and to account for the existing diversity of institutional structures and tenure arrangements regarding inland capture fisheries in particular.

To assist with operationalizing the policy, the Technical Committee for Drafting of the NIFAP also laid out short-term, medium-term and long-term action points for implementation by the different states and union territories (Government of India, 2018b). These recognized that different outcomes as plans are adapted to diverse fisheries and to changing and socially contingent local realities. However, it also meant that critical and proactive monitoring of outcomes would be essential to safeguard fishing rights and access. In practice, there have been various challenges to implementing the NIFAP and SSF Guidelines, especially in those states with the largest inland capture and culture-based fisheries. In particular, activist groups found the lack of recognition of inalienable rights and formalization of secure tenure to be the primary challenges to the governance of inland capture and culture-based fisheries.

Draft National Fishery Policy (NFP), 2020: Implications for inland capture fisheries

Marine and inland fisheries became a focus of the Government of India during 2019 when the finance minister announced the *Pradhan Mantri Matsya Sampada Yojana* (PMMSY). The PMMSY is a policy intended to increase productivity in the fisheries sector and, to that end, encourages private investments in marine and inland fisheries and aquaculture. Against this backdrop, the draft NIFAP was merged into an overarching draft National Fisheries Policy or the NFP, 2020 that applies to both inland and marine capture fisheries, and all forms of aquaculture. Compared to the NIFAP, the NFP pays less attention to inland capture fisheries and reflects to a greater extent the growth and economic development goals of the PMMSY and is framed in terms of meeting the goals of the ‘Blue Economy’. The NFP has identified some important challenges for inland capture fisheries and states: “in inland capture fisheries, seasonal nature of fishing operations, depleted stocks in natural waters, issues related with tenure and lease rights, use of obsolete technology for harvesting coupled with low capital infusion are some of the significant limiting factors”. To address these challenges the NFP intends to enhance fish production and productivity and to introduce conservation measures in rivers and wetlands. A key objective of the NFP is to “promote inland fisheries and aquaculture through standardized operating procedures (SOPs), inputs, and farming systems for sustainable and responsible culture and capture fisheries”. A key consideration is whether a national policy based on a standardized approach can effectively address the diversity of fisheries and the myriad challenges that exist in inland capture and culture-based fisheries, and aquaculture. In the next section the types of fisheries that exist, their tenure arrangements, and the challenges that they face, are examined.

INLAND FISHERIES SYSTEMS IN INDIA

Inland fisheries in India operate in open water, enclosed water and semi-enclosed-water environments. It is important to consider how these forms of enclosures and related biophysical boundaries affect the type or mode of fishing activity (Table 1). Thus, open water fisheries are usually dominated by capture systems, which transition to extensive culture-based fisheries (including capture fisheries that have been 'enhanced' through stocking) in open water and semi-enclosed systems, and finally, intensive freshwater aquaculture with complete enclosure on a gradient of increasing intensification (Oddsson, 2020).

Table 1. Inland fisheries tabulated by modes of fishing and the physical boundaries of the waterbodies where they operate

	Modes of fishing		
Physical boundaries of waterbodies	Capture (including culture-based fisheries where capture is the dominant mode)	Culture-based fisheries	Freshwater aquaculture, including capture-based aquaculture
Enclosed	Natural warm- and cold-water lakes, ponds, disused waterbodies	Human-made tanks, ponds, lakes, reservoirs	Fish farms, pond carp culture systems, hatcheries, livestock–fish integrated systems, human-made tanks
Semi-enclosed	Floodplain wetlands (*beels*, *haors*, *mouns*, oxbows), lagoons, brackishwater lakes, irrigation canals	Floodplain wetlands, natural freshwater and brackishwater lakes, rice–fish systems, irrigation canals, integrated/composite systems, e.g. rice–fish	Cage culture, prawn culture within or adjoining other waterbodies and hydrologically connected during the flood season
Open	Rivers and floodplain channels, streams, estuaries	Rivers or floodplain wetlands with established populations of exotic fishes	-

In the following sections the nature of the fisheries in some of the main fishing environments in India are considered, including the types of fishing activity, the tenure arrangements that govern them and the main challenges that these fisheries face.

Environments and institutions in inland capture fisheries: An overview

Rivers, streams and floodplain wetland fisheries

Modes of fishing: Capture (rivers, streams), culture-based fisheries (floodplain wetlands).

System boundaries: Open water (rivers, floodplain channels), semi-enclosed (oxbow lakes, *mouns*, *beels*, *haors*, etc.).

Major institutional regimes: State control, lease-based contracts, cooperatives, limited-access, common pool regimes or free access, collective or common property resource management.

Riverine and floodplain wetland fisheries are the mainstay of capture fishery systems in the rivers of the Indus–Ganga–Brahmaputra plains and peninsular large rivers, such as the Mahanadi, Godavari, Krishna, Narmada and Wainganga (Sinha, Khan and Jha, 1999; Biswas and Boruah, 2000; Pathak *et al*., 2000; Vass *et al.,* 2011). River floodplain fisheries usually have limited technological development or motorization of fishing boats (Figure 2, George, 1971; CIFRI, 2004; Santha, 2008a; Singh and Kumar, 2014; Purkayastha and Gupta, 2014). Riverine capture fisheries can be transboundary in their characteristics and exhibit strong 'upstream–downstream' differences in the types of fishing and species compositions.

Figure 2. A fisher sets out to fish on the Ganga River

Reflecting the dynamic nature of rivers and the seasonal flood cycle, daily and seasonal fisher mobility are features of these environments, evolved as adaptive responses to track mobile and migratory fish. Such mobility can extend beyond the state-defined spatial domains of their rights. In additional to subsistence and commercial fishing, recreational inland fishing is an emerging business in India, allied closely with commercial (often high-end) river tourism interests (Gupta *et al.*, 2015). Trout (*Oncorhynchus mykiss* and *Salmo trutta*) introduced during the colonial era in Nilgiris District as well as mahseer (*Tor* spp.) have been the focus of the recreational fisheries (Pinder and Raghavan, 2013), often based on catch-and-release. Recreational fisheries are chiefly located in Karnataka, Uttarakhand, Himachal Pradesh, North Bengal, Arunachal Pradesh and Nagaland (Joshi, 1988; Sehgal, 1999a,b; Mandal *et al*., 2018; Nautiyal, Babu and Behera, 2013).

In addition to the stream and river fisheries are the important floodplain fisheries. River floodplains are the most productive open water fisheries and can support large human populations (Hoggarth *et al.*, 1999; Dudgeon, 2011; Welcomme *et al*., 2010; McIntyre *et al*., 2016). The floodplains are connected to river channels, especially during flooding, enabling exchanges of material and energy among river channels and the wider floodplains (Thoms, 2003). As such, river floodplains represent highly dynamic open water ecosystems, their boundaries constantly changing due to hydrological and sediment dynamics (Bhargava, 2007; Rudra, 2010).

Summary of tenure arrangements in river, stream and floodplain fisheries: Various forms of tenure arrangements are associated with river fisheries including individual rights to fish based on riparian landowning, leasing and collective rights. In some cases, the types of arrangements have changed over time. For example, in Odisha, leasing of river stretches for one to three years to cooperative societies was the practice, but more recently the access rights lie with the people residing along the banks of the river. In Assam, lease-based systems (*Mahalwari*) on rivers have been practised for a long time on many reaches along the Brahmaputra (Biswas and Boruah, 2000; Borah *et al.,* 2014; Saikia, 2019). Tenure arrangements also reflect the dynamic nature of rivers and fisher mobility: mobile fishers commonly arrive at informal tenure arrangements through social bonds and local networks with other fishing groups across large

riverscapes (Kelkar, 2014b). A common form of tenure in rivers, canals and tanks is for the state to maintain management rights and lease the waterbodies in the dry season but allow local people access rights to fish in the monsoon flooding and postmonsoon flow recession periods (e.g. Upadhyay, 2003; Pandit *et al*., 2016).

In some locations access to rivers and other waterbodies is affected by religious restrictions. For example, the Ganga River in Uttar Pradesh has numerous pilgrimage centres located along its banks, where temple authorities have historically banned fishing in the vicinity of *ghats* and other religious worshipping sites (Doron, 2013). These arrangements are legally codified in the Uttar Pradesh Fisheries Act (1948). Within the recreational fishing sector some cooperative management models are beginning to emerge and evolve (Gupta *et al.*, 2015; Mandal *et al*., 2018). Typically, local fishing communities are employed as guides or support staff in recreational operations. Such arrangements raise questions on equity and fair contracting terms between recreational fishers and local fishers.

The transboundary nature of larger rivers means that there may also be different tenure arrangements on different stretches of the same river. For example, on the Gandak River, which flows along the borders of Uttar Pradesh, Bihar (India) and Nepal, three different arrangements operate. The stretches in Uttar Pradesh are managed under an auction-lease system for capture fisheries with access rights to specific river segments leased to private commercial contractors. The contractors then employ fishers to harvest on their behalf, including those from the same state as well as other states. By contrast, in the state of Bihar the state effectively created an open access fishery. The Gandak also flows through a small section of Nepalese territory, where the capture fisheries are managed under a community rights system. If the river splits into braided channels along these boundaries due to the formation of mid-channel sand bars and point bars, the rights to use different braided channels also vary from year to year.

In contrast to the river fisheries, which are mainly wild capture fisheries, river floodplains support a combination of capture, culture-based fisheries and freshwater aquaculture. In some states, stretches of rivers continue to be leased to private bidders through auctions held by the state fisheries department (as in Uttar Pradesh). In culture-based fisheries, a wide range of actors is involved, including fishers' cooperatives, self-help groups (SHGs), individual lessees and commercial contractors. In auction-lease or contract systems in both capture and culture-based fisheries, use of hired migrant fishers by contractors is a regular practice. In these systems, allowances to hired fishers and subsistence use rights can vary. Small-scale culture-based fisheries by individuals or community-based groups may take place in privately owned or leased ponds. Other forms of leasing arrangements include cooperative-based management, where the state recognizes members' rights and members can bid for leases, with some states giving preferential rights to members over external private bidders. In wetlands and ponds, leases to fish are granted to bidding entrepreneurs through auctions conducted by cooperatives (Jha, 2009). Often, such waterbodies are worked through intensive practices of stocking and harvesting (Figure 3).

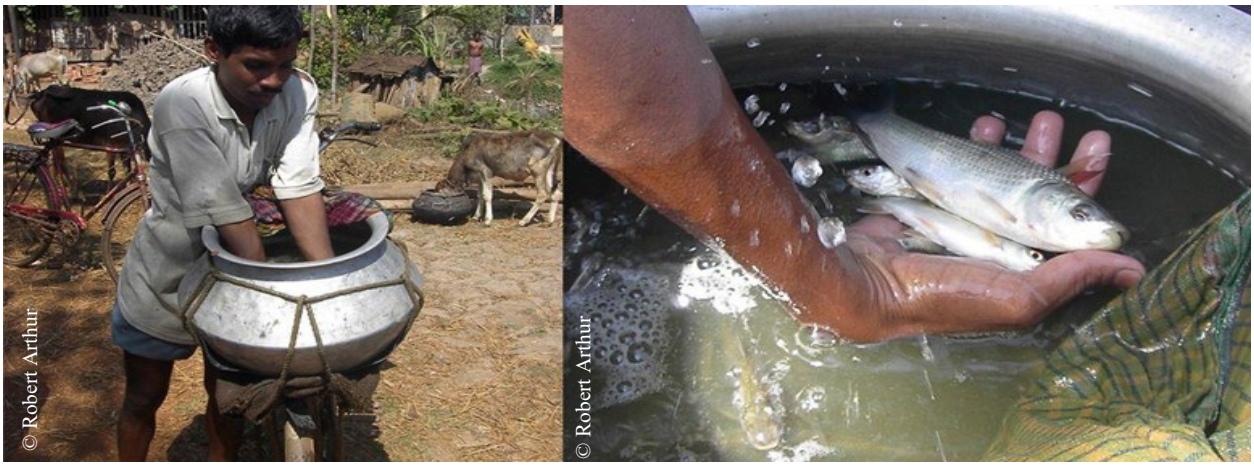


Figure 3. Many wetland waterbodies are stocked to create culture-based fisheries. Here fish seed is being transported by bicycle in West Bengal

In addition to the formal leasing arrangements, there are also important informal tenure arrangements that enable people access rights in river and floodplain fisheries. Due to flooding, side-channel inlets or braided channels become connected. This results in many informal transactions, ranging from allowances to conflicts between different fishing and farming groups over access rights (Deb and Haque, 2014; Kelkar and Krishnaswamy, 2014).

Threats and drivers of change in river, stream and floodplain fisheries: Apart from the existing impacts from dams, barrages, and pollution, climate change, economic development and a renewed interest in large infrastructure projects are among significant future changes that could impact the productivity of riverine capture fisheries (Sinha and Khan, 2001; Vass *et al*., 2009; Badjeck *et al.,* 2010; Das *et al*., 2013a,b, 2016; Das, Sarkar and Roy, 2019). These drivers can modify environments and create uncertainties that could limit knowledge systems and the capacity for adaptive management of riverine capture fisheries (Dey *et al*., 2020). Examples of climate change impacts include more extreme rainfall events, overall temperature rise and frequent droughts and glacial melt in rivers of Himalayan origin (Whitehead *et al*., 2015; Anand *et al*., 2018). Such changes have affected water temperature, physico-chemical properties and hydrology, altering fish community composition in some rivers (Saha, Das and Bhaumik, 2007; Sarkar *et al*., 2012; Das *et al*., 2013b).

Infrastructure projects that can affect inland fisheries include river interlinking projects (see Bandyopadhyay and Perveen, 2007 for an economic feasibility analysis) and development of industrial inland waterways (Kelkar, 2016), which both affect fish biodiversity and fisheries productivity (Lakra *et al*., 2011; Sarkar *et al*., 2012; Grant *et al.,* 2012). In the Gangetic Plains, negative impacts on inland capture fisheries (in particular because of dams and barrages) have been witnessed on the Ganga (Farakka Barrage) and the Ghaghra, Gandak and Kosi rivers (Shetty and Malhotra, 1983; Ray, 1998; Adel, 2001; Suresh *et al.,* 2017). The most dramatic declines are associated with the Farakka Barrage (commissioned in 1975) that impacted the migratory clupeid hilsa shad (*Tenualosa ilisha*), which moves upriver during the postmonsoon season to spawn. Hilsa shad became commercially extinct soon after the barrage construction, in the river reaches upstream of Farakka (Mirza, 1998; Ray, 1998). The Farakka Barrage also impacted downstream rice paddies and fisheries along the Padma River in Bangladesh and has been implicated in large-scale environmental-driven distress migration into India (Swain, 1996b). Further threats to river floodplains include habitat degradation, chemical and thermal pollution, overexploitation and flow alterations (Pantulu, Alagaraja and Bhimachar, 1966; Jhingran and Sugunan, 1988; Talwar and Jhingran, 1991; Yadava and Sugunan, 1992; Dubey and Ahmad, 1995; Sinha, Khan and Jha, 1999; Pathak *et al.*, 2000; Marmulla, 2001; Dudgeon, 2000; Dudgeon, 2011; Tockner and Stanford 2002; Vinci *et al*., 2003, Allan *et al*., 2005; Arthington *et al*., 2006; Vass *et al*., 2009, 2010a,b; Sharma *et al*., 2014; Nandi, Tewari and Shah, 2016).

Measures have been identified that could mitigate some of these impacts, including ensuring minimum ecological and environmental flows. However, there is an urgent need to estimate the current and future impacts of flow regulation by dams and barrages on the productivity, biodiversity and ecosystem services from riverine capture fisheries. Ecological and environmental flows also need to be assessed for riverine capture fisheries across India to inform river restoration and improved flow management (Joshi *et al*., 2014; Johnson, Sivakumar and Rosenfeld, 2017). Other measures to address impacts from barrages include attempts to design bypasses to allow 'assisted migration' of hilsa shad, currently being undertaken by CIFRI, and proposals to enhance riverine capture fisheries through pen-culture systems or ranching of native river fish species.

Within river floodplains the intensification and expansion of freshwater aquaculture have been identified as important drivers of change in the capture fisheries. This is due to a combination of the collection of fish and spawn from commercially important species such as the Indian major carps (Dubey and Ahmad, 1995; Jhingran and Ghosh, 1978; Rahman, 2008) and the increasing enclosure of floodplain waterbodies. Associated with enclosure, pre-existing customary arrangements, allowing temporary use and access, are being reshaped and brought under formal and more rigid systems contracts, leasing and cooperatives (Edwards, 2003; Santha, 2008b; Deacon, 2012; Katiha *et al*., 2017). As a result, local access rights for many involved in capture fisheries are increasingly derived from a complex mix of legal and customary arrangements (Upadhyay, 2003; Katiha, Sharma and Chandra, 2013). An effect of the ecological and institutional changes is that capture fisheries systems are becoming sedentary, i.e. showing a predominance

of fixed trap-gears in recent years (Kelkar, personal observation). There is a concern that this might make them more vulnerable to flooding or other disasters (Mishra, 2009).

Some measures have been identified to mitigate some of the impacts of environmental change in river floodplains. Small indigenous freshwater fishes (SIFFs) are present in river floodplain capture and culture-based fisheries (Figure 4). These fish are often important in local food systems, providing an affordable source of highly nutritious fish that can be purchased in small quantities (Feagan, 2007). They can also be an important part of regional trade networks, for example in Northeast India, where the Jagiroad Market in Assam is an important trade hub. As a result, efforts are being made to promote the conservation and exploitation of these fish to address goals of rural nutrition, poverty alleviation, food security and fish biodiversity conservation (Kumar, 2010). However, the promotion of SIFFs has legal implications as SIFFs are frequently harvested using fine-meshed nets, which are illegal under most state fishery laws.

Figure 4. Sacks of dried small fish being prepared for transport to markets

Reservoirs, human-made tanks, ponds, lakes and other wetlands

Modes of fishing: Freshwater aquaculture, culture-based fisheries.

System boundaries: Enclosed (freshwater aquaculture tanks, artificial lakes, fish farms, industrial hatcheries, human-made tanks), semi-enclosed (such as dam reservoirs, village tanks, farm ponds, sewage ponds, derelict waterbodies with culture-based fisheries).

Major institutional regimes: Private leases and contracts, cooperatives, state control, community-based fisheries and mixtures of multiple coexisting arrangements.

Reservoir, lake, tank and pond fisheries (Figure 5) involve mixtures of capture fisheries and culture-based fisheries and may even be used for freshwater aquaculture, with differences in the way rights and tenure are granted. These types of fisheries are widespread in India. In Madhya Pradesh, Rajasthan, Maharashtra, Andhra Pradesh and Tamil Nadu, small to large dams are significant contributors to capture as well as culture-based fish production, involving production of stocked major and minor carps as well as other native species (Sugunan, 1995, 2000; Department of Animal Husbandry, Dairying and Fisheries, 2007, 2012). It is believed that it is possible to further increase reservoir fish production (van Zwieten *et al*., 2011) as the sector is thought to be underutilized in terms of actual versus potential production (Sugunan, 1995, 2000; Boopendranath *et al*., 2002; De Silva and Amarasinghe, 2009; Miao, De Silva and Davy, 2010).

Figure 5. Small household pond used to culture fish

Widespread extension programmes, along with the easy and cheap availability of fish seed (including fry, larvae and spawn), herbicides, insecticides and fish antibiotics, have all contributed to freshwater aquaculture intensification across the country (Jhingran and Sugunan, 1988; Veerina *et al*., 1999; Srinath, 2001; Pillai and Katiha, 2004; Chandra, 2012; Tyagi, Bisht and Pal, 2015; Das, Rao and Kulsreshtha, 2018). Industrial or factory-like fish hatcheries began to appear in the 1970s, for example with the intensive culture of mahseer in Maharashtra (Sehgal, 1999a). Due to the high capital and technological inputs involved, the spread of these types of fish hatcheries has been relatively slow in other areas. Fish-cage culture is also being promoted significantly across different aquaculture systems (Das, Mandal and Mukhopadhyay, 2009), and the National Fisheries Development Board (NFDB) has recently funded development of cage-culture projects.

At more local scales, culture-based and enhanced or stocked capture fisheries have developed mainly in ponds, reservoirs, tanks and floodplain wetlands (Pant and Verma, 2010; Ghosh and Indu, 2010). Culture-based fisheries and aquaculture (including cage and pen culture) are practised in many freshwater environments, not limited to floodplain wetlands, oxbow lakes, *haors*, *beels* and *mouns* (Sinha and Jha, 1997; Sugunan and Bhattacharjya, 2000; Sugunan *et al*., 2000; Ambastha, Hussain and Badola, 2007; Joshi and Kumar, 2009; Jha, 2009; Chandra, 2010, 2011). Many of the smaller examples, such as ponds, human-made tanks and reservoirs, urban tanks or ponds are managed at the level of small floodplain settlements, often with customary community-level rights being maintained (Das, 2006; Dey and Prein, 2006; Tyagi, Bisht and Pal, 2015). West Bengal and Assam appear to have a particularly high level of culture-based fish production in *beels* and even in sewage settling tanks, canals, and ponds known as *pukurs* (Kumar, 1992; Sugunan and Bhattacharjya, 2000; Sugunan *et al*., 2000; Abraham, Sil and Vineetha, 2010). In Madhya Pradesh, farm ponds, called *balram* ponds are now being used for freshwater aquaculture.

Tenure arrangements in reservoir, tank and pond fisheries: Reservoir management remains state-managed and top-down in nature, or is leased to private bidders, corporate businesses and in some cases, to tribal groups or fishers' cooperatives. Responsibility for stocking the reservoirs as part of the management mandate often lies with the government departments and local fishers continue to have limited stakes in managing reservoir culture-based fisheries (Sugunan, 2000). Calculations of lease values in reservoirs differ widely across different states, and there are different procedures used to determine lease value including reserve pricing (as in Gujarat and/or Maharashtra) or calculations based on estimates of fish stocks (as in Assam or Madhya Pradesh). Often, contractors do not register lease agreements to avoid paying revenues of between 3 percent and 7 percent to the government that are a requirement in some states. Madhya Pradesh follows a public-private-people-cooperatives-partnership model in managing the state's large reservoirs.

Culture and harvesting rights are preferentially extended to displaced people living within 1 kilometre of the reservoir boundary. The functioning of these cooperatives was found to be more effective where dam-displaced fishers were involved in their management (Tyagi, Bisht and Pal, 2015). In addition, fish sellers are obligated to sell at least 10 percent of their catch in local fish markets, and the leased rights to sell fish (by private parties) are differentiated from the rights to harvest fish (by fisher members of registered cooperatives). In Rajasthan, reservoirs stocked and managed by private contractors recorded significantly higher revenues and better management than those managed by tribal cooperatives. Limited investments and differences in capital, lack of training together with arbitrary and confusing leasing procedures were associated reasons.

Reservoir-based cooperative societies are another form of tenure and are known to be functioning with some promise in Palakkad District of Kerala. The Dimbhe Dam cooperative in Pune District, Maharashtra, has also been a success story through their work with multiple government departments in charge of reservoir management. In the Tawa Reservoir of Madhya Pradesh, Jyotishi *et al.* (2020) indicated that reservoir productivity showed punctuated but consistent improvements over time, as a function of institutional change and changing production efficiency. They looked at three periods of institutional management: state controlled (1974-1985), partial and full privatization (1985-1994) and cooperative management by the Tawa Matsya Sangh or TMS collective (1996-2006). Fish production increased and technical efficiency of production and management of fish sales peaked and remained stable under the cooperative management regime. Stocking under the TMS was also much greater than under the earlier private regimes. Interestingly, the royalties paid by the TMS to the state fish federation (similar to lease prices) increased from 1997 to 1998 to 2000 to 2001 and then gradually declined by 2006 (Jyotishi *et al.*, 2020).

In dam reservoirs, fishery departments often give preferential leases to fisher or tribal cooperatives, or to families displaced by dam construction and inundation. In forested regions where conservation areas and reservoirs overlap, e.g. Odisha, fishing rights are sometimes (but not uniformly) recognized for cooperative societies, combined with Community Forest Resource Rights (CFRs), and are included in the framework of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.

Governments typically lease wetland areas through open tender systems for widely variable periods, ranging from one to five years. Informal leases, including long-term leases, are a feature of culture-based fisheries in human-made wetlands. Many of the arrangements in small waterbodies such as ponds and backwaters have derived from traditional rights. Kerala's fishery policies have also granted culture and harvesting rights to traditional fishers since 2010, through ongoing processes to formally recognize pre-existing informal arrangements in ponds, backwaters, rivers and paddy fields (rice–fish systems).

Across culture-based fisheries, the diversity of ownership and fish culture rights is high, with culture and harvesting rights likely to be invested with pond owners, lessees, cooperatives, SHGs[6] or regular farmers, including small-scale freshwater aquaculture in composite fish-farming extension programmes. Intensive freshwater aquaculture systems are owned mostly by companies, private entrepreneurs or by some state governments. In smaller ponds and *beels* local fishing communities can undertake their own stocking programmes. Small ponds may also be leased by *panchayats* to SHGs, cooperatives or even individuals for between one and five years. In general, longer periods of leases could ensure more secure access rights for the lessee, although it is recognized that this would also exclude others who may have an interest in fishing for longer. A successful example of *panchayat* control comes from Odisha (e.g. Sambalpur). Minor or subsistence uses of ponds may be allowed for non-members of culture-based fishery cooperatives, if this is not perceived to affect the benefits to the cooperatives (Hodgson, 2016). Such arrangements typically allow for subsistence use by local villagers but prohibit any commercial uses.

Drivers of change and threats to reservoir, tank and pond fisheries: The growth of freshwater aquaculture and culture-based fisheries has had various environmental and social impacts. Issues affecting reservoirs include lack of monitoring, undermining of cooperative functioning, unequal sharing arrangements between lessees or contractors and fishers, the use of destructive fishing practices and pollution. In smaller waterbodies, water pollution in sewage ponds has become a concern associated with

[6] Local village enterprises, called self-help groups, often involving women and rural farmer households.

an increased prevalence of ulcerative fish diseases (Das and Das, 1993; Das, 2018). Freshwater aquaculture is becoming a major consumptive user of water taken from surface water storages and groundwater sources (Adhikari *et al*., 2017), and a contributor to environmental pollution and eutrophication of waterbodies (Ayyappan and Jena, 2001; Barange *et al*., 2018; Edwards, 2015). To address this, new technologies are being developed aimed at reducing these pressures by introducing greater efficiency in water use, polyculture practices and waste recycling (Ramsundar, 2011; Mohanty *et al.,* 2017). In Odisha and Andhra Pradesh, the impacts of prawn aquaculture have been damaging for brackishwater capture fisheries and action is needed to address pollution from prawn *bheris* and resulting conflicts. The spread of freshwater aquaculture and culture-based fisheries is also associated with the introduction of exotic fish species to inland waters across India (Singh and Lakra, 2011). There are concerns that under suitable ecological conditions, exotic species may establish themselves and outcompete native fish (Canonico *et al.,* 2005; Laxmappa, 2016). From a biodiversity perspective, there is a need to introduce stronger quarantine rules to reduce this risk and prevent the introduction of exotic species that may become invasive fish species (Ponniah and Sood, 2002; Singh and Lakra, 2011).

The increase in culture-based fisheries and aquaculture has also had social consequences. Traditionally, in waterlogged and flood recession wetlands or estuaries, customary rights related to easements were regularly enjoyed by fishers, but over time, private landowners along waterfronts have denied access to fishers. Even relatively secure tenure systems in Kerala's inland capture and culture-based backwater wetland fisheries have witnessed contestations over the use of potentially destructive and illegal fishing practices by unauthorized fishers without tenure rights (Ramachandran, 2008; Santha, 2009). In enhanced reservoir capture fisheries, contract-driven leasing systems might have aggravated social inequities, as state departments typically issue licences or lease rights to contractors who make large profits while employing fishers on basic wages (Sugunan, 2000). Fish (especially the major carps) from freshwater aquaculture and culture-based fisheries are also dominating sales in fish markets across the country (Ganesh Kumar *et al.,* 2008, 2010a), and are usually cheaper and with more stable prices than wild fish from capture fisheries. Furthermore, market access and support, insurance arrangements, price regulations and postharvest resources are still weak or unstable in rural inland capture fisheries (Sathiadas and Narayankumar, 1994; Little *et al.,* 2002; Kumar, Joshi and Katiha*,* 2003, Ganesh Kumar *et al.,* 2010a,b; Jha, 2009; Paul and Chakraborty, 2016; Parappurathu *et al.,* 2017).

Estuarine and brackishwater fisheries

Modes of fishing: Wild capture, culture-based, capture-based aquaculture (mainly prawns).

System boundaries: Open water (estuaries), semi-enclosed (lagoons, backwaters).

Major institutional regimes: State control, common pool, limited access.

Estuarine and brackishwater capture and culture-based fisheries are highly productive fisheries along all coastal states, especially West Bengal, Odisha, Kerala and Andhra Pradesh (Mitra *et al.,* 1997; Jha *et al.,* 2008). Their productivity is attributable to both resident and migratory species, and they support large fishing populations (Mitra *et al.,* 1997). Shrimp and mollusc fisheries in estuarine areas (Figure 6) can be especially productive (Payne *et al.,* 2004). Fisheries in estuarine areas and coastal lagoons can also provide important opportunities for women: for example, in the Sundarbans, many women are involved in prawn seed collection and fish drying and processing (Ghosh *et al.,* 2015; Mitra *et al.,* 2017).

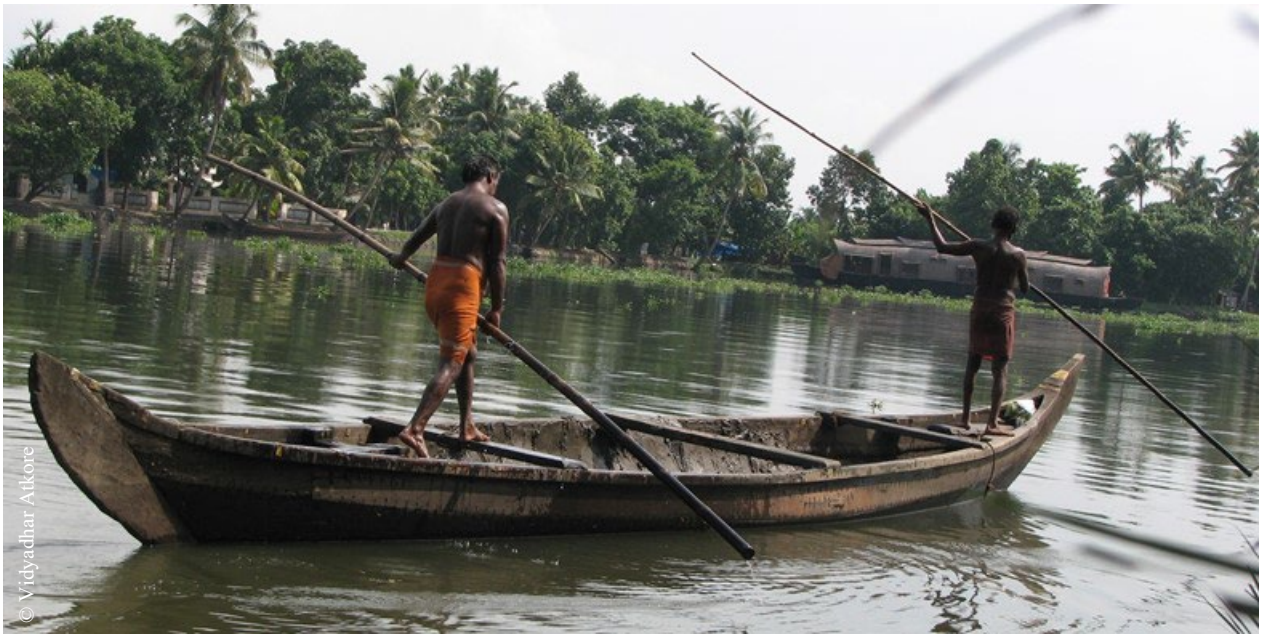


Figure 6. A boat in the Vembanad Estuary, Kerala

Tenure arrangements in estuarine and brackishwater fisheries: As estuarine capture and culture-based fisheries are dependent on spatial gradients of tidal influence, management systems are often complex, involving limited rights, but also free access and migratory fishing in tidal rivers (e.g. the Bhagirathi–Hooghly tidal river system) and by spatially limited tenure in lagoons (Chacraverti*,* 2014). In the case of Chilika Lake, Odisha, groups that are considered traditional have customary rights to fish with fixed gears (Nayak, 2014). In the shallow part of the lake, leases are given to fishers' cooperatives by the revenue department, many of which are used for capture-based aquaculture of prawns in large enclosures.

Chilika also features a complex rotational system based on village-level leasing of spaces to deploy fixed fishing gears for capturing wild fish (Iwasaki and Shaw, 2009). This rotational system is based on a combination of: 1) fishers using only fixed box-and-stake nets (gillnets and the active netting or fish driving are banned in parts of the lagoon); 2) net locations being specified in the waters adjoining different island-based and shore-based fishing villages; 3) the numbers of nets and gears to be used in these fixed spaces being decided by the local village bodies holding the management rights and managing the system, similar to territorial use rights (e.g. Mathew, 1991). In line with the rules of this system, the positions of individual fishers' nets are rotated according to tidal cycles, to allow all fishers to benefit from incoming and outgoing fish flows (Nayak and Berkes, 2011). Associated with this system, local fishers regard Irrawaddy dolphins (*Orcaella brevirostris*) as a helpful species, believed to push fish into their nets while foraging (D'Lima *et al.,* 2014). Without the existence of this practice, positive perceptions towards Irrawaddy dolphin conservation might not have evolved. In addition to the rotational fixed net arrangement, in the shallow part of the lagoon, leases are granted to fishers' cooperatives by the revenue department for prawn culture within large, enclosed areas. Illegal prawn culture has also been recently expanding along the lake margins, leading to local conflicts with capture fisheries. Additionally, an increase in boat-based ecotourism centered on dolphin-watching has led to some impact on fisheries management under the earlier system.

In these fisheries, conflicts between fishers using active fishing gears and fixed fishing gears, and conflicts between capture fishers and culture-based fishers (especially in prawn culture), are frequently witnessed. Examples of such conflicts have been recorded in the Chilika and Kolleru lagoons on India's eastern coast (Ramakrishna, 2002; Iwasaki and Shaw, 2009; Nayak and Berkes, 2011; Nayak, 2014). In the Sundarbans of West Bengal, capture fisheries were not under state or private control even in the colonial period; (Barman, 2008; Ghosh *et al.,* 2015), but their space is now shrinking both due to expansion of conservation areas and increasing human impacts on the Sundarbans (Danda, 2007). Conservation initiatives are not only the responsibility of the state but also of local fisher groups. In the enhanced capture fisheries of the Vembanad Estuary in Kerala, fishers have themselves actively formed nursery protection zones called

matsyathavalams (Teli *et al.,* 2014). In Kerala's estuaries, community-driven collectives have integrated with state management of culture-based and capture fisheries (Srinivasan, 2002).

Threats and drivers of change in estuarine and brackishwater fisheries: Sea-level and salinity rises, impacts of cyclones and coastal erosion, eutrophication, decline of mangrove belts and reduced freshwater flows by upstream dams/barrages on rivers draining into them, are some of the major factors leading to fishery declines in estuarine regions (Hazra *et al.,* 2002; Danda, 2007; Manna *et al.,* 2010; Asha *et al.,* 2014). As well as environmental changes, conflicts among capture fisheries and wildlife-conservation-related interests (bans on fishing, non-recognition of fishing rights, spatial restrictions on accessing protected mangrove forest areas, reserve and protected forests or afforestation plantations in catchments) are considered to have intensified in the last few years across different regions (Chacraverti, 2014).

Upland fisheries in cold-water environments and natural lakes

Modes of fishing: Wild capture, capture-based aquaculture and culture-based fisheries.

System boundaries: Enclosed or semi-enclosed (saline lakes, cold-water lakes, tropical freshwater lakes).

Major institutional regimes: State control, cooperatives, private culture, village-level commons.

Cold-water capture and culture-based fisheries mainly exist in high-elevation mountain streams, rivers and natural lakes in Jammu and Kashmir, Ladakh, Himachal Pradesh, Uttarakhand and Sikkim (Sehgal, 1999b; Petr and Swar, 2002; Sharma and Mehta, 2011; Pandey *et al.,* 2012). Examples of natural cold-water lakes include the freshwater Dal and Wular lakes of Kashmir, Loktak Lake in Manipur as well as saline lakes (e.g. Sambhar Lake in Rajasthan). Fish are generally absent in the high-salinity inland lakes like Sambhar and Lonar Crater lakes, although in the Sambhar Lake of Rajasthan fish have been found during years with higher monsoon rainfall when flash floods or inflows into the lake periodically reduced salinity. In Pangong Tso and Tso Moriri lakes of Ladakh, a few snow trout species (Schizothoracinae) exist, which local villagers harvest (Sharma and Mehta, 2011). In Ladakh there is currently interest in exploring options for the development of cold-water culture-based fisheries.

Tenure arrangements in upland fisheries: For the most part these fisheries follow similar arrangements to other stream and small waterbody fisheries although in some hill streams and cold-water lakes, Buddhist or Hindu religious beliefs limit the extent and access provided to capture fishers.

Threats and drivers of change in upland fisheries: Environmental change has been a key driver in upland fisheries, with fish kills attributed to temperature rise, pollution and eutrophication, which have been damaging to snow trout and carp production. Himachal Pradesh and Uttarakhand are also promoting snow trout farms, but a combination of rising temperatures and infrastructure limitations have prevented major growth of cold-water aquaculture in these states (Pandey *et al.,* 2012). Invasion by aquatic plants is another major threat to cold-water fisheries systems (Sandilyan *et al*., 2018). In Jammu and Kashmir, Qureshi and Krishnan (2015) highlighted negative impacts of tourism and eutrophication caused by floating vegetable garden markets on culture-based production of snow trout and carps in the Dal and Wular lakes. These authors also highlighted the importance of treating lake capture fisheries at the same level as other commercial activities.

Fisheries in irrigation canals and tanks

Modes of fishing: Wild capture, capture-based aquaculture, culture-based fisheries.

System boundaries: Semi-enclosed (irrigation canals, hydropower channel links and feeder canals).

Major institutional regimes: Leases to private contracts, state-regulated, commons.

Capture and culture-based fisheries (with enhanced and stocked capture fisheries) in irrigation canals and other local water diversion channels date to the time when large-scale canal irrigation systems were developed (Das, 2003).

Tenure arrangements in irrigation system fisheries: Irrigation canals usually support culture-based and capture fisheries by individuals under private or cooperative leases (Figure 7), but also under free access in some cases (Pandit *et al.,* 2016). In Uttar Pradesh, stretches of irrigation canals are usually leased for periods of up to three years to private contractors known as *thikadars*, e.g. in the Ghaghara Canal network. In Andhra Pradesh, only one-year leases to fish in tanks are provided. Usually, *panchayats* manage these access rights through a system of auctions for the tanks known as 'endowment tanks 'that were provided to villages by the local governments. The extent of culture-based fisheries in canals tends to be proportional to the densities of canal networks found in states (e.g. canals along the upper Ganga–Yamuna, Punjab, Farakka feeder canals, Ghaghara Canal, Mahanadi Canal networks and the Godavari–Krishna Canal) and is dependent on seasonal irrigation schedules.

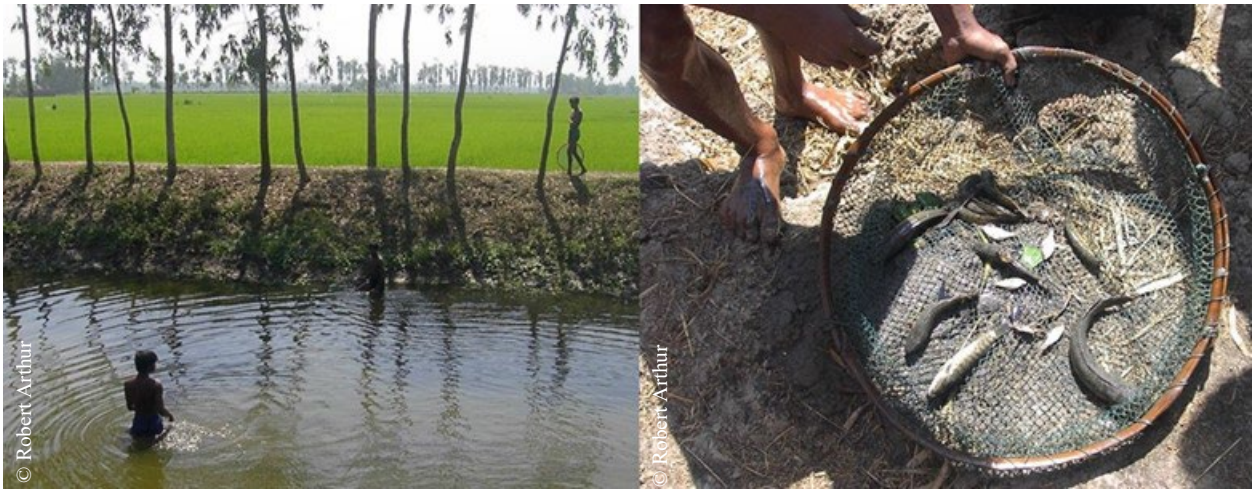


Figure 7. Subsistence fishing and fish catch in an irrigation canal

In many cases, irrigation departments or dam/barrage authorities are granted rights to stock and harvest fish in canals, instead of state fisheries departments, typically during the dry season or irrigation seasons. Often, irrigation tank/canal systems have been managed as multi-use waterscapes for many generations, with irrigated rice paddies and culture-enhanced tank fisheries representing the main water demands in Southern India (Natarajan and Ghosh, 1980; Khan, 2010). Many such tank systems have changed hands from private forms of management (e.g. the Malguzari tanks in Vidarbha) to village-level and cooperative management over time, although earlier water-sharing agreements may be retained. Smaller irrigation systems may be managed by villages or farmer groups and in these systems subsistence access rights may be granted to local fishers.

Threats and drivers of change to irrigation system fisheries: One of the main threats to fisheries in irrigation canals is how the water is managed. The timing of releases of water and the opening and closing of sluice gates can affect the ability of fish to move around the system and between the system and natural waterbodies. The creation of irrigation canals has created opportunities to fish and this has also led to fishers' self-organization to manage the fishery, ensuring access and opportunities to fish. While there has been some development of culture-based fisheries and aquaculture in canals, which has involved invasive and exotic fish species, associated study has been minimal to date and it is not clear to what extent this might be a threat. However, it is known that culture-based fisheries in the tanks associated with the irrigation systems have led to some conflicts with fishers in the canals.

Integrated or composite culture-based fisheries

Modes of fishing: Wild capture fisheries, culture-based fisheries and aquaculture.

System boundaries: Semi-enclosed (rice–fish, rice–shrimp systems, aquatic cropping systems), enclosed (livestock–fish culture-based systems).

Major institutional regimes: Private farm level, village-community level, state-controlled.

Dhawan and Sehdev (1997) listed rice–fish, poultry–fish, dairy–fish, duck–fish and fish–swine systems as the major types of integrated or composite culture-based and capture fishery systems. In these systems, the wastes from the non-fishery component are utilized and metabolized by fishes, making these systems both productive and low input. This reduces the costs of fish culture and allows for all-round benefits to fisheries and beyond. Other forms of composite culture-based fisheries involve the integration of fish with aquatic plants in both extensive and intensive production systems to form aquatic cropping systems. Aquatic cropping systems are also composite crop–fish systems and occur throughout the country in floodplain wetlands, ponds, lakes and reservoirs (Jha *et al.,* 1991, Jha 1995, 2009; Vinci *et al.,* 2003). Probably the best known are the rice–fish systems that in India have been historically prevalent in the high-rainfall and heavily irrigated regions of Kerala, West Bengal, Orissa, Assam and other states of Northeastern India (including Assam, Arunachal, Meghalaya) and Tamil Nadu (Willcocks, 1930; Natarajan and Ghosh, 1980; Bayan, Das and Dutta, 1996; Kojeen, 2001; Das, 2002; Halwart and Gupta, 2004; Aditya, Pal and Saha, 2010). Monsoonal flooding and flood-dependent irrigation in turn lead to the seasonal inundation of rice-growing areas that encourages populations of fish and aquatic invertebrates (Shaji and Laladhas, 2013).

Apart from their small-scale, low-capital and high-yielding status, studies have found that larvivorous fish help to control mosquito breeding, and their sale provides additional income for rice farmers (Das, Rao and Kulsreshtha, 2018). Rice–fish systems, including in rice fields and in the margins of deeper waterbodies, allow for both capture fisheries and the possibility for seasonal culture-based fisheries, given the influx of wild fish and the potential to introduce fry, fingerlings and larvae of fish and prawns into the waterbodies (Das, 2002; Talukdar and Sontaki, 2005; Rautaray, Dash and Sinhababu, 2005; Das, Mandal and Mukhopadhyay, 2009). Both capture and culture-based fisheries are found in the rice paddies and floodplain waterbodies associated with the low-lying plains, deltas and mountain-valley terracing systems of rice cultivation, especially in West Bengal, Northeast India and as deep-water rice–fish systems in coastal and brackishwater regions (Das, 2002; Rai, 2005; Rautaray, 2007; Saikia and Das, 2008; Das, Mandal, and Mukhopadhyay, 2009). Different varieties of rice are used, with deep-water varieties of rice being extensively used in the culture-based fisheries in West Bengal and Assam (Das, Mandal, and Mukhopadhyay, 2009; Das 2002; Sinhababu *et al.,* 2006).

In addition to rice, other common and commercially important aquatic crops include water chestnut (*Trapa* sp.), fox nut (*Euryale ferox*) and lotus (*Nelumbo* sp.), as well as other species harvested for roots and fruits (Jha, 2009). These aquatic cropping systems host many valuable species of floodplain-resident 'blackfish' such as snakeheads (*Channa* sp.), climbing perches (*Anabas* sp.), some catfishes (e.g. *Heteropneustes* sp., *Clarias* sp.) and gouramis (*Colisa* sp.), which are adapted these types of environments. Snakeheads and climbing perches from aquatic cropping systems are in particularly high demand. The highest production of aquatic crops comes from the states of Bihar, West Bengal, Assam, Maharashtra and the central Indian region (Jha, 2009). In North Bihar, entire families are involved in aquatic fish-cum-crop systems, known as *maachh–makhana*. While the fish from aquatic cropping systems are mostly consumed locally, or dried and sold in markets, the crop yield provides the main income for fishers in Bengal, Assam and Northeast India (Debnath *et al.,* 2012; Narayanan, 2016). Many waterbodies where aquatic crops are grown are formed from flood-spillage waters due to embankment breaches and ruptures along North Bihar's floodplains (Sinha, 2008; Singh *et al.,* 2009; Mishra, 2009; Jha, 2009). The same wetlands are used regularly for seeding and culture of Indian major carps, which are grown alongside native species making these important systems for economic development and management (Ahmad and Singh, 1997; Kumar, 2012).

Tenure arrangements in integrated fisheries: Across India, customary access, rights and subsidiary forms of tenure have maintained themselves alongside formal tenure rights (Robb, 1988; Beck and Nesmith, 2001). As dynamic fishing environments, rice fields can have tenure arrangements that shift between collectively and individually held management rights and between open and more exclusive access (e.g. Gregory, 1997). As the floodwaters rise, the fields become inundated and the boundaries between fields become submerged. At this point, when fish are moving from dry season refuges or between fields, customary rights allow people to catch fish from the rice field and the temporary channels carrying receding floodwaters in the postmonsoon season. As the waters begin to recede and the boundaries become clearer, individual tenure is recognized and access may become more restricted, although some access rights may still be allowed for subsistence fishing by local households. These are informal rights and the people fishing may not be officially recognized as fishers. There are also examples of individual farmers creating trap ponds within

their rice fields to collect fish as the floodwaters recede (Halwart and Gupta, 2004). The management rights for these small waterbodies are held by the individual farmers, and they can represent an important additional source of food and income for the farming households (Shoemaker *et al.*, 2001).

Threats and drivers of change to integrated fisheries: These types of fisheries are affected by climate and environmental change that may affect the animal, plant and fish components. Intensification of crop and fish production in these systems could also worsen the ecological condition of waterbodies through increased concentrations of pollutants and biocontaminants (especially herbicides and pesticides) and the escape of exotic species. It is also not uncommon for pesticides to be used by the injured party to kill fish in ponds with disputed ownership (Kelkar, 2012). In some cases, aquaculture can be a response to mitigate or adapt to environmental degradation. For example, in the Punjab where there are experiments with inland saline-water aquaculture (Ansal and Singh, 2019). Salinization of groundwater has been a negative outcome of intensive irrigated farming. The growth of aquaculture in the state has been largely due to migrant Bihari workers who have managed to obtain leases for aquaculture ponds (Moudgil, 2016).

Urban and peri-urban inland fisheries

Modes of fishing: Wild capture and culture-based fisheries, aquaculture.

System boundaries: Semi-enclosed (ponds, wetlands).

Major institutional regimes: Lease-based contracts, cooperatives, state-controlled.

While inland fisheries are often presented as a rural occupation, there are also significant urban and peri-urban fisheries in India. Urban and peri-urban areas are considered to have important differences to rural areas, both in the importance of cash income and the monetary economy with a more limited set of natural resources (Kadfak, 2019). Urban and peri-urban fisheries are evident in brackishwater areas. Mangrove fisheries in India support the second largest populations of fishers in the world, but the focus is on non-urban settings (zu Ermgassen *et al*., 2021). Urban and peri-urban mangrove-associated fisheries receive less attention. Pressures from urban development are significant on the mangrove fisheries around the Vembanad Estuary backwaters in the corporation areas of Kochi and Ernakulam in Kerala, in the Zuari Estuary in Goa and the estuaries along Greater Bombay (Mumbai city). In the Kochi area, fisheries are the main economic and livelihood activity of local people who are dependent on mangroves and the capture and culture-based fisheries that they support.

The East Kolkata Wetlands in West Bengal are one of the best-known peri-urban fisheries, probably on account of their scale and proximity to the city of Kolkata. Much less is known about urban and peri-urban aquaculture in wastewater lagoons in other smaller cities and towns in the state (Bunting and Lewins, 2006; Butsch and Heinkel, 2020). The wetlands lie adjacent to the eastern edge of Kolkata. They perform important ecosystem services based on natural ecological processes, including urban wastewater treatment and urban food supply, providing Kolkata with around one-third of its daily fish supply.

The East Kolkata Wetlands originated as a brackish backwater swamp of the Bidyadhari River (Kundu, 2010). Traditionally the area was used for rice cultivation and subsistence capture fisheries (Hettiarachchi and Morrison, 2017). The expansion of the city during the colonial period and challenges with waste disposal led to the wetlands being identified as an alternative to disposal of waste in the Hooghly River (Panigrahi and Pattnaik, 2020). Over time the role of the wetlands in regulating water quality has evolved, with up to 1 million cubic metres of wastewater from the city passing through the wetlands daily (Bhattacharya *et al.,* 2012; Kundu, 2010). The changes in the wetland environment created opportunities to develop wastewater-based agriculture and fish production in *bheris* of up to 40 hectares. Productive fisheries are based on natural processes of organic waste decomposition within the ponds that support plankton production (Bhattacharya *et al.,* 2012). Over time, the area used for inland fisheries reached up to 12 000 hectares. However, due to urban expansion, this has declined over time to around 4 000 hectares (Datta, n.d.).

Tenure systems in urban and peri-urban fisheries: The waterbodies around urban areas typically belong to private landowners, although some also belong to the state. These holders of management rights will

lease the waterbodies for fisheries. Landowners are commonly absentee landlords and management of the fisheries is largely undertaken by the leaseholders, who may be individuals, cooperatives or groups of fishers. In many urban lakes (including human-made reservoirs or tanks), such as those in the cities of Bengaluru or Hyderabad, naturalized populations of exotic fish species such as tilapia (*Oreochromis mossambicus*) and common carp (*Cyprinus carpio*) form the mainstay of the fisheries. Fishing in these lakes was initially open access but is now increasingly leased to private contractors who get annual or three-year leases to fish and who stock the waterbodies (Sen and Nagendra, 2020).

Threats and drivers of change in urban and peri-urban fisheries: Critically, urban development and the need to regulate freshwater quality have led to important changes in both the wetland environment and the nature of the fisheries. Capture fisheries in rivers of the Gangetic Plains located near large urban centres have been under pressure from riverside infrastructure development, embankment constructions and increased vessel traffic. Fishers around cities like Allahabad, Patna and Kolkata along the Ganga and Hooghly riverfronts, have reported that they are able to fish in fewer locations along the river (Kelkar, 2012; Panigrahi and Pattnaik, 2020). Estuarine and mangrove regions face extreme pressure from reclamation of mangrove lands for residential development and enclosure of estuarine areas for shrimp aquaculture (Jayahari, K.M., personal communication). Expanding shrimp aquaculture under private business ventures has reduced areas once freely accessible to fishers. Sea-level rise additionally threatens estuarine regions by changing the habitat conditions and the composition of fish catches (Mani Murali and Dinesh Kumar, 2015).

Diversion of anthropogenic wastewater into the East Kolkata Wetlands has changed the environment and the management of water flow and water quality into the wetland has enabled a shift from a capture-based fishery system to one dominated by pond-based aquaculture production. These changes have been facilitated by aspects such as access to larger markets providing more consistent and reliable demand as well as wastewater use that reduces expenditures on fertilizers and feeds (Bunting and Lewins, 2006). While the wastewater enhances productivity, there can also be issues with water pollution from domestic and industrial sources. Similar issues affect many of the urban lakes. Changes in production practices mean that it has become rare to see any native fish being harvested from these systems. Being located within or near urban areas can also mean risks from airborne pollution and theft by poachers (Bunting and Lewins, 2006). However, the most significant threats relate to urban encroachment, siltation and land conversion (Hettiarachchi and Morrison, 2017). Despite the contraction of many of these wetlands, these processes have been resisted. The successful maintenance of the fishery in the East Kolkata Wetlands for example has been attributed to some awareness in the city administration along with organization among fishers. This includes the cooperatives, organization and unionization, even under the private landowners (Hettiarachchi and Morrison, 2017).

Summary of tenure arrangements in fisheries

The aquatic environments across India provide the basis for a diverse range of fisheries. The tenure arrangements associated with these fisheries are equally diverse with a range of actors possessing management and access rights. There are examples of both formal, legally recognized rights, informal rights based on customary practices (although these may be considered formal at the local level) and combinations of formal and informal rights. Furthermore, in some of the larger waterbodies there may be different types of these fisheries, also representing different tenure arrangements, operating in the same waterbody, for example cage culture, extensive culture-based fisheries and subsistence fishing for wild fish in a reservoir.

There is evidence of changes in the fisheries and in the tenure arrangements in many fisheries environments. One clear trend is the increase of stocking and shifts towards culture-based fisheries and aquaculture. This process can be facilitated by the leasing arrangements in many waterbodies. The development of culture systems transforms the fisheries from an extractive system, based on natural productivity, to more input–output-oriented systems that may be less dependent on maintaining natural cycles. Furthermore, there may be shifts from continuous harvesting to periodic harvests as the dependency on the stocked component of the fishery increases. Associated with this trend is increasing floodplain enclosure and more commercial investment in obtaining leases to grow fish and employment of fishers to harvest fish.

A growing trend has been to allow limited access and cooperative-based management of river stretches for capture fisheries and small-scale culture or enhancement through the formation of village fishing committees, instead of granting leases to private contractors and entrepreneurs, e.g. in Bihar (Kumar *et al.,* 2018). In many states, allocations of leases to enclosed waterbodies have been decided on different classes and categories of different waterbodies. In other cases, tension can result in fisheries that feature both formal and informal arrangements that allow for subsistence use.

GOVERNANCE OF INLAND FISHERIES

Institutional structures, norms and regulations affect how rights are realized, and how management responses to change could evolve (Ostrom, 1990, 2005; Young, King and Schroeder, 2008). In many inland fisheries in India the state continues to play a strong role and there are many examples of collective arrangements, both formal and informal, that can organize action related to resource use.

In legal terms, the ultimate responsibility for inland waterbodies and inland fisheries lies with the respective states. Inland fisheries are on the state list of the Indian Constitution. Therefore, the articles of the Constitution of India, guaranteeing peoples' rights and duties towards freedom, dignity, survival, labour, livelihoods and the environment are intended to provide the fundamental basis of state-level fisheries acts. Fishers have a vital role in the management and utilization of inland waters and maintaining access rights is an important priority (ICSF, 2014). Due to historical land-centric ownership, water and fisheries tenure was either subsumed under private riparian lands or maintained largely through customary and ad hoc access. In fisheries there has been a trend of increasingly formalizing customary rights and regulating access, and entrusting tenure decisions with the state fisheries departments. In these cases, the choice is between legal granting of specific management and/or access rights by the state or recognizing certain pre-existing customary rights. State departments other than those charged with fisheries also need to have formalized laws to protect fish in open waterbodies managed by them. However, in practice the role of state government agencies tends to be restricted to acting as trustees and retainers of inland fishery resources and their direct involvement in management is limited.

Because of this situation, alongside state agencies, private interests and cooperatives also appear as important formal institutions governing inland fisheries in India. These institutions interact mostly via systems of licences and lease contracts for use rights that are allocated through auctions. In many cases, there are specific membership criteria related to cooperative membership or who is eligible to bid for leases. In some states, there is legal recognition of customary fishing rights (but not culture rights) in some waterbodies (Kumar, Joshi and Katiha, 2003). Culture and harvesting rights from Indian fisheries environments vary but tend to broadly align with the differences in enclosure of waterbodies (Adger and Luttrell, 2000; Edwards, 2003).

Tenure represents institutions (i.e. sets of formal and informal rules) that influence the relationships between individuals and groups with respect to the benefits that can be derived from inland fisheries. Generally, four typical tenure arrangements have been identified: state agencies, collective, individual and open access, as they relate to both rights and access or property (Nayak and Berkes, 2021). These arrangements can be formal, informal or a combination of the two. In this section the different forms of institutional arrangements concerning management and access rights that have been identified in Indian inland fisheries are described. These include examples where management rights have been removed as well as the different ways in which management and use rights, both formal and informal, have been allocated and negotiated.

State-held rights

Management rights to capture and culture-based fisheries in inland waterbodies are generally entrusted or vested with the block-level (subdistrict) administrative divisions of state fishery departments (Kumar, Joshi and Katiha, 2003; Katiha, Sharma and Chandra, 2013; Chandra, 2011). These divisions then become the common arbiter of tenure, rights and ownership issues. They are responsible for providing access rights in the form of capture/culture rights through leases, licences, and periodically renewed contracts to cooperatives, scheduled caste and scheduled tribe (SC/ST) fisher groups, individual fishers (where fisheries are limited access) and private contractors, usually in that order of priority (Sinha and Katiha, 2002; Katiha, Sharma and Chandra, 2013). Fishers are therefore encouraged to become members of block-level cooperatives (Jha, 2009). In some states, fishing villages are given a special status so that they can be involved in decision-making as *panchayats* (e.g. Tamil Nadu), tribal councils (e.g. Assam, Meghalaya) or as groups with traditional and customary community rights (e.g. the *mallah* fishers of Bihar).

A frequently used measure to limit access rights is for state fishery departments to issue licences to individual fishers. In many states, licences have been a means to recognize and formalize customary rights based on definitions of fishing dependency or social status. In practice, licence types can vary depending on

whether fishers are operating as members of the local block-level cooperatives or not. Criteria for whether individuals can hold a licence include membership, having certificates demonstrating they are fishery-dependent users, caste identity, proof of fishing as a traditional occupation (including full-time, seasonal or part-time), proof of being below the poverty line or being landless. These criteria are revised regularly. However, the monitoring of licences is not regular and this allows fishers to enter the fishery without licences.

State fisheries departments are often not independent or fully autonomous in their structure and functioning, being nested under the agriculture or animal husbandry departments. In cases where capture fisheries are transboundary (either interstate or internationally), management decision-making involves interactions between the central and state governments as these are considered 'national' rivers and waterways. In terms of their operation, good coordination and dialogue are observed in a few states, e.g. Odisha, where the implementation of fisheries management plans has involved officials from the environment, tribal welfare, agriculture, revenue, water resources and animal husbandry departments, among others. However, in many cases the state departments face important challenges in their management. Limitations include ill-equipped and insufficient technical staff (20 percent to 60 percent vacancies across most states), a lack of basic research capacity, a lack of review of financial resources, poor capacity in maintenance of records and limited extension programmes. These factors all affect the effectiveness of the departments to contribute to the development of inland fisheries.

Collectively held rights

This section concentrates on two examples of collectively held rights: the formal, legally recognized form of the cooperative and other rights held or assumed by various groups that may or may not be formally recognized.

Cooperatives

According to the National Federation of Fishers Cooperatives Ltd. (FISHCOPFED), there were 20 639 primary fishery cooperative societies (as of 2019) with over 3 million members in total, including both marine and inland fishers. Of these, up to 15 000 were inland capture fisheries and aquaculture cooperatives that were distributed in all states and union territories of India. Unfortunately, it is not possible to separately identify cooperatives that are focused on wild capture fisheries. However, it is generally recognized that most cooperatives have been established to engage in culture-based fisheries and aquaculture (Box 7).

Box 7. The role of cooperatives

The original vision of cooperative institutions was provision of credit, marketing services and input supplies to local fishery stakeholders (Allison and Badjeck, 2004; Hussain and Bhattacharya, 2004; Deacon, 2012; Tyagi, Bisht and Pal, 2015). Cooperatives are not supposed to function in isolation, but rather work in partnership with public and private enterprises, including businesses, state agencies, investment banks and insurance agencies. Cooperation between the state and fishers is therefore an assumed working principle.

It has been observed that farmers often use agricultural cooperatives in their area as little more than outlets for sale of high-yielding seeds, fertilizers or agricultural tools. Similarly, fishers also depend on cooperatives mainly for accessing individual welfare schemes (which may or may not be related to fisheries), memberships and identity cards.

For fishers to gain access and secure even temporary fisheries access rights, cooperative membership of the block in their residential area is often critical (Tyagi *et al.,* 2013). In this regard, the potential of cooperatives for bottom-up engagement, which can ensure transparent, accountable, environmentally responsible and equitable management of fisheries, becomes limited.

In a mixed economy, cooperative institutions have been regarded as a balancing institution between communities and the state (Deacon, 2012; Kalikoski and Franz, 2014). Cooperative by-laws and administrative tiers differ across states and union territories in India, pointing to different levels of decentralization and autonomy. In Odisha, for example, there are four tiers of cooperative institutions (from districts to villages: *gram sabhas*), as compared to Bihar, which has only two (district and block-level).

Cooperatives are not without their critics. A report by the Ministry of Agriculture's High-Powered Committee on Cooperatives (2009) identified the "overwhelming role of the government" to be a major challenge in the autonomy and democratic character of cooperatives. This points towards a 'democratic deficit' in cooperatives (Birchall, 2004) as they currently operate. The report also found inadequacies in governance, communication and active functioning, as well as lack of recognition of cooperatives as economic institutions by policy-makers, to be strong hurdles in the social and economic function of cooperatives.

Interference in cooperative functioning by locally powerful elites with political access has been witnessed regularly in the Gangetic Plains (Kelkar, 2012). This contributes to widespread corruption, favouritism, and biased benefit-sharing mechanisms. Other limitations include low fund and infrastructure provision by state and central governments. Lack of awareness about government programmes, funds and infrastructure limitations, guidelines, and schemes for fishers' welfare represent other major gaps.

Owing to the current limitations of cooperative functioning, the preference of state agencies has been to ignore cooperatives in favour of private entrepreneurs, which leads to further weakening of cooperative functions. Despite this, some cooperatives, having been successful in terms of economic returns and efficiency, have usually implemented culture-based fisheries in reservoirs and tanks, e.g. the Dimbhe Dam cooperative, Pune, Maharashtra) and floodplain wetland fisheries (in Assam). The East Kolkata Wetlands represent an encouraging example of community-led management of cooperatives, with 50 percent of benefits shared with participant fishers. Perhaps as a result, cooperatives have gradually risen to be the primary node through which leases and licences are granted in capture and culture-based fisheries. Where they are successful, cooperatives can deliver important social benefits to their members. They include provisions for education, health care, child care, literacy, community development and awareness about culture-based fishery schemes and technical developments. The Bon Hooghly Cooperative, North 24 Parganas, West Bengal, is a good example, with permanent lease rights to a lake providing the basis for establishing an education or community centre and the provision of other amenities for members.

At present, FISHCOPFED's objective has been to ensure at least 33 percent representation of women in existing cooperatives. Women have high levels of participation in certain fisheries, for example the *beel* fisheries in states like Assam, and there is scope to revive existing cooperatives or address demands for women's cooperatives. In neighbouring Bangladesh, women's fisheries cooperatives have recently been expanded and have been associated with improvements in floodplain wetlands management. Greater involvement of women in the functioning of cooperatives has also yielded positive outcomes compared to male-dominated cooperative agencies (Jassal, 2003; Nandeesha, 2004; Kumar and Talluri, 2016). Although cooperative control can extend to all waterbodies in principle, their involvement is usually restricted to enclosed waterbodies with culture-based fisheries (Tyagi *et al.,* 2013).

Community rights

Community rights represent examples where the rights of the members of a group or 'community', collectively and individually, have received legal recognition or codification. Examples include Meghalaya, where collective rights regarding fishing activities in streams and wetlands have been formally recognized for those residents of villages near Manipur's Loktak Lake based on existing forest rights (Meghalaya Piscicultural Societies Rules, 1986). Tribal councils and villages hold management and access rights based on a combination of locality and active participation in fishing activities or allied businesses for specified periods of time. In the Malguzari tanks of Vidarbha, some types of community rights have been recognized for the Dhinwar fishers' groups. Community-based tenure arrangements have been reported in many stream and wetland fisheries and in freshwater aquaculture systems, either through legally defined or customary community rights (e.g. Radhyeshyam, 2001; Das, 2006).

The changing nature of inland fisheries in India and the gradual formalization of tenure arrangements mean that many traditional systems based on community rights are currently marginal. Despite this, some rights are being recognized, including through broader policy instruments. For example, fish may be considered as a non-timber forest product and added to forest access rights granted through licensing or permits issued under the Forest Rights Act (2006). Other examples include the access rights for scheduled tribal groups in states including Jharkhand, Chhattisgarh, Madhya Pradesh, Maharashtra and Andhra Pradesh. These rights are formalized through the Draft National Tribal Policy. The Supreme Court's judgement of 2011 is important in this regard, as it notes that common lands must be treated as inalienable, and the vesting of the commons with the state did not mean that common rights of the community were lost by such vesting. The court ruled that as community rights over disputed lands were not created by landholders (or by the state), they could not be abrogated by other existing acts.

Religion and fishing tenures

Fishing access to rivers and other waterbodies is affected by religious restrictions in some capture fisheries. For example, the Ganga River in Uttar Pradesh has numerous pilgrimage centres located along riverbanks, where temple authorities have historically banned fishing in the vicinity of *ghats* and other religious worshipping sites (Doron, 2013). Such barriers to access are not just informal arrangements but are also legally codified in the Uttar Pradesh Fisheries Act (1948). In some hill streams or cold-water lakes, Buddhist or Hindu religious beliefs also limit the extent and access provided to capture fishers. These examples illustrate an important point that waterbodies can be imbued with important spiritual or cultural values and this can mean that other livelihood or economic activities must be restricted.

Rights assumed by informal groups

While community-based or traditional institutional arrangements are frequently described as 'informal', in fact they tend to have a certain legitimacy both to local people and to the state. Indeed, to those governed by these arrangements they may seem no less formal than state legislation and may be more influential in shaping behaviours. However, there are also informal arrangements whereby more powerful groups or individuals assume some control over resources and can restrict access. For example, following the creation of open access fisheries in Uttar Pradesh and Bihar, organized criminal groups linked to political interests were able to begin influencing the terms on which people could fish through the use of violence, threats or other forms of harassment (Kelkar, 2014a,b). The violence in these matters underscores how fishing rights are entwined with basic human rights in ways that extend beyond rights to food (International Law Commission, 1990; Allison *et al.,* 2012; Ratner, Asgard and Allison*,* 2014; FAO, 2017). Here, safety of human life and well-being become more immediate pressing priorities. As access rights granted under such regimes violate other established laws, rules, and legal or policy prescriptions made by the state, they have been described as 'impossible' rights (Hodgson, 2016).

Individually held rights

Private ownership (combining management and access rights) is the primary form of control for freshwater ponds and aquaculture farms developed on private lands. In other semi-enclosed and open water systems, including river stretches, access rights are obtained through systems of leases granted periodically through auction. These are granted to interested private contractors, where cooperatives do not bid, cannot bid, are not considered eligible or where private contractors might provide greater or securer revenue (Deacon, 2012). It is important to distinguish within individually held rights, the management rights and the access rights of both the leaseholder and of those undertaking the fishing under the lease.

Management rights provide an opportunity to generate income from the leasing of access rights. In some cases, e.g. large reservoirs, the leaseholder is also responsible for stocking, although in other systems stocking may be undertaken to increase the perceived value of the fishery and hence increase the lease price. In other cases, the right to stock, together with the right to exclude others, is granted as part of the lease. For the leaseholder, the lease system creates an incentive to maximize the returns from the system, including increasing the productivity and minimizing the costs. Outside the cooperative system, where commercial operators obtain leases, they will often hire fishers to guard and harvest the fish. In this respect, the lease

systems can create new contractual relationships that determine fishing activity and the benefits that can be derived from it.

Labour arrangements in fishing activities, including fish harvesting, postharvest processing and transport, have increasingly involved temporary and contractual labourers, many of whom may be migrant workers (Singh *et al.,* 2011; Kumar and Bhagat, 2012). Over 10 million people may be actively engaged in inland capture fisheries and aquaculture across India. These workers are often from more economically marginal groups within or outside traditional fishing castes or groups (Pokrant, Reeves and McGuire*,* 1997; Barman, 2008; Kelkar, 2014a). Fishers across the Gangetic Plains receive lower wage rates than the daily minimum wage rules in most cases and in general, labour contracts and wages are typically decided based on informal, arbitrary and precarious terms and conditions (Kelkar, 2014b).

Open access fisheries

The key characteristic of open access fisheries is that everyone can participate in the fishery and that no effort is made to regulate where, when or how they fish or what they catch (Arthur, 2020). The primary concern is that, in the absence of other controls, those benefiting directly from harvesting have little incentive to restrict their own use, and self-interest therefore tends to lead to overexploitation (Gordon, 1954; Hardin, 1968). This concern is often the basis for regulating fisheries. However, across inland fisheries this unregulated open access is rare (e.g. Baird, 2010) and there are numerous examples of fisheries where, while the number of fishers is not restricted, restrictions are applied, for example on what can be caught, how and where. As with the example of the flooded rice fields, these forms of regulated open access may, for example, allow fishing for subsistence purposes.

Open access conditions may occur when the perceived value of the resource to the holder of management rights is insufficient to merit actively regulating the fishery, where capacity to regulate access is lacking (de facto open access), where new waterbodies are created or where a decision is actively made to deregulate or to effectively remove the basis for claiming rights. In cases where open access conditions are created, local people may respond by creating their own forms of regulatory and tenure arrangements (e.g. Sharkey, Arthur and Daniels, 2021; Kelkar, 2018). As the example from Bihar illustrates (see Box 8), fewer conditional access rights that provide more freedom to meet their needs may be preferred to the more restrictive arrangements experienced working under private control. Furthermore, in open access or regulated access fisheries there may be no need to pay or demonstrate identity as a traditional fisher. Thus while open access fisheries (including regulated open access fisheries) are frequently identified as a matter of concern, their social function and buffering impact on vulnerable caste groups and impoverished rural poor also needs to be acknowledged (Jul-Larsen *et al*., 2003; Arthur, 2020), especially in the absence of alternative effective social protection measures (Béné, 2009, Béné, Hersoug and Allison, 2010; Sharma, 2017).

Box 8. Free the Ganga: Changes in access arrangements in Bihar State

In Bihar State, large stretches of the Ganga River were privately owned and access rights to them leased to local fishers. In 1991, following pressure from a social movement involving fishers called the *Ganga Mukti Andolan* or Free the Ganga Campaign (Gupta, 1993; Sharma, 2006), private property rights were removed by the state government to essentially create open access fisheries in all flowing rivers of the state (Bharti, 1991; Gupta, 1993). Women's involvement and leadership were noteworthy in this process, and women continue to be engaged and vocal about fisheries issues in the river (Sharma, 2006, 2017).

Fishing the River Ganga

One of the consequences of the change in the system was that, in the aftermath of 1991, organized gangs, recognizing the value of the fishery, began to control the access of small-scale fishers to the fishery by extorting money. Resistance to this resulted in violent conflicts (Kelkar, 2018; Kelkar and Krishnaswamy, 2014; Kelkar, 2014b). Benefiting little from the fishery, the state fisheries department was not motivated to tackle such risky issues (Narayanan, 2016). What is also interesting to note is that, despite the extortion by the gangs, many fishers appeared to tolerate the risks associated with the system, preferring them over the oppressive arrangements under the private fishery owners that had existed for 400 years prior to 1991 (Kelkar, 2012, 2014b; Kelkar, 2018).

Contested rights and struggles to legitimize claims

Access rights are often granted to fishers by the state based on their traditional fishing occupations and livelihoods (Datta, 2014; ICSF, 2019). Here, there is scope to critically look at what being identified as 'traditional' fishers means from a political standpoint (Kelkar, 2018). Self-identification as traditional fishers, fishworkers or fishing communities can enable them to stake claims to management and access rights, although this may be affected by considerations of who can be legitimately recognized as fishers by the state under different state acts. In practice, definitions of fishers vary from state to state based on caste, tribal or traditional identity, proximity to waterbodies, social recognition of fishing as their traditional occupation, gender and gender-based involvement in fisheries, fishing as a primary activity, seasonal fishing patterns, labour migration, training in fish culture (especially for small-scale aquaculture farmers) and investment in fishing operations. Furthermore, identity as a fisher may, in practice, be inseparable from caste identity.

Caste-based or identity-based fishing rights routinely involve difficult contestations and caste-based politics. The legal emphasis on formalizing the rights of traditional fishers might have increased social barriers to the granting of access rights to scheduled castes (e.g. in Andhra Pradesh; Sharma, 2015) or intensified caste-based negotiations for exclusive access rights (e.g. Bihar, Bagchi, 2018). At present, the lack of a clear definition of who can or should be considered as fishers, and the contested nature of identity when linked

to the ability to benefit from the fishery, has had implications for the management of tenure and for basic estimates of the numbers of people engaged in inland fisheries and aquaculture in India. This issue can be especially important for vulnerable groups, such as women fishworkers, whose rights may depend on them being defined as fishers. For example, in Kerala, women obtaining benefits or access to welfare schemes only as fish sellers or as dependents of fishers (e.g. widows).

Recognition as a traditional fisher or fishworker is based both on self-identification and political manipulations, representing a 'grey space', with stable legal definitions unlikely to be arrived at by both the state and fishing communities (see Kelkar, 2018). This requirement to establish a legitimate identity and the way that it can become politically contested is perhaps another reason why fishers can appreciate, or in some instances prefer, open access fisheries due to fewer barriers or constraints.

Further issues can arise from the formation of clubs and cooperatives. In practice this can be challenging given the often diverse sets of social and economic groups that depend on inland fisheries. The cooperative establishes a limited set of beneficiaries. This can have important implications for some of these groups who may find themselves excluded; for example traditionally migrant fishers may lose access rights. How the benefit sharing arrangements are established may also be affected by the activities of powerful individual groups who seek to ensure that they benefit from the cooperatives (Kelkar, 2012).

Where inland fisheries are perceived by groups to be valuable, they have sought to advance claims to rights or (as in Bihar) have taken advantage of the opportunity provided by the absence of institutional arrangements to benefit. Fishers have responded to the effects of state regulation, leasing arrangements and the operation of the cooperatives through collective action to demand increased local-level access rights. Within waterbodies there may be different fishing practices and technologies that can be a source of conflict, including between capture fisheries and aquaculture (for reasons of economic exclusion or environmental externalities), among fishing groups using different gears (based on perceptions of the impacts of fishing practices) and among groups based on social identities (e.g. traditional or caste-based).

Struggles and conflicts also extend to other sectors. This can include fishers versus farmers (over enclosure of waterbodies, abstraction and pollution of water, and the management of water in irrigation systems), fishers with infrastructure developers, e.g. in the case of the Farakka Barrage (Box 9) or urban development that encroaches on the fishing environment (e.g. the East Kolkata Wetlands). Again, fishers organize to take collective action to have their rights recognized. Given fishers' aspirations for economic development, education, accessible health care, urban amenities and social security, it becomes important to examine the relevance of fishing rights for communities placed at the juncture of difficult choices.

Summary

Tenure comprises bundles of interconnected rights in relation to management and access that can be held in different combinations by the state, individually and collectively. These tenure arrangements also overlap with multiple other land and water use and tenure regimes. However, what is critical comes in terms of access, who benefits and the relationships between actors, individually and collectively. In this respect, the ongoing shift towards more formal systems established to extract rents that began in the colonial era is significant. There are two important features of these systems. The first is that the amount paid for leases will reflect the perceived value of the resource or the potential returns from increasing productivity. In both cases, the holder of the management rights or the lessee are incentivized to increase the returns from the fishery and adopt culture practices to do so. These arrangements are also significant in that they provide rights to some, on condition of payment but, at the same time, restrict the rights of others. Thus, they are systems that feature both winners and losers.

The policy criteria suggest that in granting fishing rights through auctions, contracts or tender systems, priority should be given to local fishers over outside interests. In practice, this is not always the case. This is also important as there may also be incentives to reduce costs, for example through the hiring of fishers to harvest the waterbody. Where access rights are granted to commercial interests, exclusion of fishers may have the effect of creating a body of available and experienced potential employees that can be employed to harvest fish. This creates quite different sets of access rights for the fisher, which are based on

the interests of the commercial operators and maximizing their returns. The rights of those harvesting the fish and their ability to benefit from the fishery, are defined by the lessee. As the example of Bihar indicates, these rights, and the benefits that they can therefore derive, may not fit with the needs of the fishers.

Conversely, many of the informal customary arrangements in inland capture fisheries tend to ensure that people can meet their basic needs. These tend to be based on giving priority to fishers living near waterbodies, i.e. priority due to proximity, but can also be based on 'tradition' (Huppert, 2005). The focus of many customary tenure arrangements is to compromise on the ability to maximize individual benefits to achieve wider collective benefits. In practice, the evolution of management institutions creates conditions described by Young (2002) as 'institutional interplay'. Fisheries institutions (such as lease arrangements) interact with other institutions, such as the ability of traditional fishers to harvest fish. Resulting in negotiation of the roles of institutional arrangements and the perceived legitimacy of fishing rights (Jentoft, 2000). Resulting from this interplay are conditions on the leasing arrangements, for example leasing only to fishers or to groups from within communities. As a result, access rights in many cases represent a combination of legal and customary arrangements (Upadhyay, 2003; Katiha, Sharma and Chandra, 2013). From a human rights perspective, this is both opportunity and challenge. Traditional rights based on caste lead to forms of exclusion that limit the access rights of other groups (who may be more, or less privileged than the fisher groups). This could introduce new forms of caste-based conflicts and politics, as is being witnessed in some regions of Northern India (Bagchi, 2018).

Arguably, informal and customary tenure arrangements could allow for more flexibility and adaptiveness in decision-making than formal or legal tenure. However, this creates an alternative challenge of how customary arrangements can be recognized and how they fit within policies and wider arrangements that have different objectives. A potential starting point might be self-identification as fishers, other fishworkers or fishing communities, as a basis for staking and negotiating access more forthrightly.

DRIVERS AND RESPONSES IN THE GOVERNANCE AND MANAGEMENT OF INLAND FISHERIES

Inland fishing environments are subject to various drivers of change. Natural drivers, such as changes in water quantity, quality and the timing and duration of floods, can also affect fisheries productivity. Local tenure arrangements have often developed to accommodate this seasonal and interannual variation. There are other drivers, which are anthropogenic in nature, to which local tenure may be less adapted. These anthropogenic drivers have been categorized by Lynch *et al.* (2016a) as internal (e.g. stock enhancement and overfishing), other sectoral (e.g. hydropower and agricultural intensification) and external (e.g. population growth and urbanization) factors. They can also lead to changes in tenure arrangements and the distribution of benefits from the fisheries. In this section some of the key drivers and the changes that they are creating are described and then discussed in relation to the implications for tenure arrangements.

Internal drivers of change

Overfishing

While inland capture fisheries are based on the productivity of highly diversified fish assemblages, they can have significant impacts on aquatic biodiversity (Sugunan, Prein and Dey*,* 2006; Brooks *et al.,* 2016; Jacob *et al.,* 2019; Robinson *et al.,* 2020). This includes depleting target species as well as endangered species (*inter alia* river dolphins, crocodiles, turtles and waterbirds) through both targeted and unintentional mortality (Choudhary, Dey and Kelkar, 2014; Raby *et al.,* 2011). Other practices, such as the use of poisons, dynamite or electro-fishing can lead to pollution, habitat and biodiversity loss. Concerns about impacts can result in fishers being restricted from fishing in certain areas or habitats (Vyas, 2004). This applies not only to protected areas under the Wildlife Protection Act, but also to entire waterscapes (Kelkar, 2014a). Where the presence of active fishing communities might help generate local conservation support for threatened species this is potentially problematic. While some species, e.g. the critically endangered gharial crocodile (*Gavialis gangeticus*), may be impacted by fishing activities or considered as competitors and targeted or require interventions (Stevenson and Whitaker, 2010), other species, such as riverine and estuarine dolphins, appear to be able to coexist with fisheries in the absence of targeted hunting.

Concerns about the environmental impact of fishing have resulted in overfishing becoming a significant preoccupation within inland fisheries management. Perceptions of scarcity in India's inland capture fisheries are based on notions of 'Malthusian overfishing' (Pauly, 1990) that emerged during the colonial administration and continue to endure within conservation and management discourses. The idea is also manifested in the discourse around overcapacity (Salayo *et al.,* 2006), giving rise to the idea that there are either too many fishers, or too intensive technologies, to harvest fish sustainably. However, these arguments fail to acknowledge the historical, institutional or social and cultural processes among fishers that enable them to overcome temporary scarcity and, as a result, avoid overfishing through adaptive decision-making (Finkbeiner *et al.,* 2017; Arthur, 2020). Furthermore, in fisheries that are affected by both fishing effort and environmental changes from outside the sector, overfishing is often assumed without empirical evidence (Friend and Arthur, 2011). Not all illegal gears may lead to overfishing, just as not all legal gears may be harvesting fish sustainably.

With emerging research on the nutritional importance of small fish (Dey, Misra and Homechoudhuri, 2017), policies restricting the harvest of small and juvenile fish have been called into question (Zhou *et al.*, 2019; Pauly, Froese and Holt*,* 2016; Tilley *et al*., 2020), and the NIFAP has also suggested periodic reviews of such rules and regulations. As with 'overfishing', the impacts of fine-meshed nets (such as mosquito nets), and their role in livelihoods need to be assessed instead of simply assuming that they are negative (Short *et al.,* 2018).

Stocking and development of culture-based fisheries and aquaculture

Stocking of fish has a long history in India. Some of the key recreational fisheries were created following the stocking of fish such as trout. State and national governments have placed a strong emphasis on the development of culture-based fisheries and aquaculture (Figure 8) to increase the production of inland fish, as reflected in the Draft National Fishery Policy. The use of lease-type tenure arrangements creates an

additional incentive to intensify production to maximize both the lease price and returns on investment. Aquaculture and culture-based fisheries (Figure 8) are now common in many waterbodies (Vinci *et al*., 2003) and revenues from these systems account for a significant amount of the total fish production in India (Kumar, Joshi and Katiha, 2003; Katiha *et al*., 2005; NASO-India, 2014).

Figure 8. Fish catches from a culture-based reservoir fishery on sale in Khanapur Market, Karnataka. Note that the catches include 1) stocked Indian major carps and common carp; 2) native carps and other fish species

While culture-based fisheries and aquaculture have helped to significantly increase the production of freshwater fish, it is increasingly recognized that they do not represent a substitute for capture fisheries, either in terms of food produced or the number of people they can support (Hall *et al.,* 2013; Barange *et al.,* 2018; Karki *et al*., 2018). It is also important to consider the wider implications of the intensification of fish production through enhancement and aquaculture (Gowing, Tuong and Hoanh*,* 2006; Diana, 2009; Edwards, 2015). These include environmental impacts, market competition with capture fishers, whose market share has been reduced with the expansion of culture-based fisheries and aquaculture, and labour relations.

In brackishwater environments the conversion of agricultural land, salinization and soil degradation have proved problematic and represent impacts on other components of the food systems. Stocking to create culture-based fisheries can affect fish within the waterbodies through interspecific competition and predation. In some brackishwater fisheries barramundi (*Lates calcarifer*) is sometimes stocked. This is a relatively high-value species but, when stocked, will predate small fish and invertebrates, which may have implications for SIFF production and the benefits that they can provide. With the intensification of fish production the risk of fish diseases increases, requiring regular monitoring to ensure the health of both fish and fishers is safeguarded (Arthur *et al.,* 2002). Ulcerative diseases have become a common recurrence across inland fisheries in India in the last few decades (Das and Das, 1993). The increase in disease also creates a need for disease treatments that can affect the wider aquatic environment and that may pose a risk to both biodiversity and human health. Postharvest preservation or adulteration of fish, e.g. the use of formalin, has been found in some fish, leading to states introducing import bans and requirements for assurances that fish will be tested for formalin traces before sale and trade.

Fertilization is often a feature of the management of small ponds and reservoirs, e.g. in Madhya Pradesh, and while this can benefit the cultured fish it can impact some wild species and create pollution problems. As well as pollution from culture-based fisheries and aquaculture, escaped fish can pose a threat. Escapes of exotic species, such as the African catfish (*Clarias* spp.) have already affected freshwater biodiversity across several states (Singh and Lakra, 2011; Singh, 2014; Ranjan, 2018; Singh *et al.,* 2017). Ornamental fish culture is a rapidly growing agri-business in many regions of India and carries the risk of release of exotic species into inland waters (Rani, Immanuel and Kumar, 2014). However, the risks are not confined to exotic species. The use of domesticated native fish, such as the Indian major carps, also carries a risk that,

through escapes, the genetic diversity of native fish species can become narrower and more homogenous. This could affect the ability of the species to adapt to environmental change.

Other sectoral drivers of change

Impacts of infrastructure development

Dry season flows in nearly all rivers in India have been strongly affected by dams and barrages and river floodplain connectivity (both longitudinal and lateral) has been severely impaired, as highlighted in the Report of the Working Group on Aquaculture and Fisheries, of the 12th Five Year Plan. Altered water temperatures resulting from flow regulations have also affected physiological and migration cues of some fish, leading to breeding and recruitment failures (Sinha*,* Khan and Jha, 1999; Payne *et al.,* 2004; Vass *et al.,* 2009; Das *et al.,* 2013a; Kelkar, 2014a; Sharma *et al*., 2015). Barrages have also prevented the large-scale movement of many fish species for spawning, notably the hilsa shad and mahseer (see Box 9). Major scientific gaps remain concerning the estimation of minimum ecological flows required to maintain aquatic environments and biodiversity.

Other infrastructure developments (e.g. ports, terminals or dredging) can negatively impact capture fisheries and aquatic biodiversity. In Kerala, capture fishers using fixed Chinese lift-nets in the Kochi Estuary have been affected by port construction. Traditional systems of allocating fishing spots for the fixed nets have been affected by riverfront and coastal development, including seaplane facilities and expansion of houseboat jetties for tourism. In Goa, an increase in marinas, water sports and casinos on the rivers associated with tourism has happened at the expense of local fishers. These types of changes related to wider economic development are set to continue through national waterway project plans to transform many rivers in India into industrial and commercial waterways for navigation and transport and through plans to connect the Brahmaputra and Ganga rivers (Kelkar, 2016).

Box 9. The Farakka Barrage: The marginalization of fishers in infrastructure decision-making

The Farakka Barrage was commissioned by the Government of India in 1975 to divert water from the Ganga River to the Hooghly distributary, to prevent sediment accumulation in Kolkata Port and improve navigation. However, the Farakka Barrage had damaging consequences for capture fisheries in both India and Bangladesh. At the time of construction, there was no consultation with local fishers about the impacts they were likely to face due to the barrage (Banerjee, 1999). Even after the barrage was constructed there continued to be little or no engagement on the issues fishing communities were facing.

*Hilsa shad (*Tenualosa ilisha*), a species impacted by the Farakka Barrage*

By the early 1980s, the hilsa shad fishery was facing near collapse in the upstream Indian states of Bihar and Uttar Pradesh, with production falling by almost 97 percent (Sinha, 2004; Saha *et al*., 2011; Bhaumik, 2017). Prior to barrage construction, hilsa shad, an anadromous migrant, would migrate to spawn, travelling over 2 000 kilometres upstream to Allahabad and even Kanpur in Uttar Pradesh.

The barrage effectively blocked their migration route and mitigation efforts have included the construction of fish locks (passes) in the barrage and a sanctuary established on the Ganga River downstream of the barrage, mainly to prevent the capture of small-sized and immature fish. The effectiveness of these measures has been questioned. The social consequences of the loss of the fishery have been significant. The Farakka Barrage has been considered an important contributor to environmental migration of rural communities from Bangladesh into India and subsequent ethnic conflict (Swain, 1996a).

Fishing communities in both India and Bangladesh have frequently expressed strong opposition to the Farakka Barrage. The *Ganga Mukti Andolan*, a social movement led by fishers in Bihar, has held the barrage responsible for the declines in hilsa shad and other important migratory species, including both fish and crustaceans. The fishers also conducted demonstrations against the barrage in the 1990s (Banerjee, 1999). Local fisher unions continue to be concerned with the welfare of fishers, protection from river erosion caused by the barrage and issues with the bans on fishing.

Water pollution and eutrophication

High levels of toxicity in fish across almost all waterbodies are a serious concern. Pollution sources include point and non-point agricultural sources (fertilizers and pesticides), sewage (the dominant source of water pollution), solid wastes, domestic wastes, plastics and microplastics, industrial wastes, effluents, oil spills, and in some cases, radioactive wastes (Hameed *et al.,* 1997; Sinha and Khan, 2001; Das, Samanta and Saha, 2007; Gadgil and Heda, 2009; Jha, 2009; Vaseem and Banerjee, 2016; Das, 2018). Fishing nets also contribute to plastic pollution in rivers (Nelms *et al.,* 2021). Furthermore, increases in macrophytes because

of eutrophication causes hypoxia in wetlands and can lead to fish kills, while siltation has affected the spawning and nursery grounds of many fish species (Das, 2002; Das *et al.,* 2013a, 2016). Changes in water quality can also affect fishers. Fishers in open water environments, may face increased occupational health risks and disease exposure, e.g. fungal infections, from contact with water and toxic responses (Pukkalla and Sharma, 2014).

External drivers of change

Climate change and population growth

Environmental pollution and water diversion and abstraction impacts become more serious in the context of climate change. Changes in the quantity and distribution of summer and winter rainfall, increases in extreme rainfall events, increased glacial melt, altered seasonal patterns and increasing recurrences of high-intensity droughts and floods are likely to affect fish habitats and stocks. It is possible that capture fisheries and freshwater aquaculture might respond differently to climate change. Capture fisheries might be negatively affected given the reliance on natural cycles, whereas aquaculture productivity might increase (at least in the short term) due to climate-induced advancement of breeding, and expansion of freshwater, saline and brackishwater aquaculture into new regions (Das*,* 2017; Sarkar *et al.,* 2018). Recently, FAO identified inland capture and culture-based fisheries as systems with high productivity and potentially representing climate-smart approaches to fish production (FAO, 2013a). Examples of climate-smart types of culture-based fisheries and aquaculture technologies identified by the Global Technology Watch group are brackishwater culture, periphyton-based (detritus and vegetation-based) aquaculture in wetlands (Ghosh *et al.,* 2019), pen culture (Chandra, 2010), cage-culture, rice–fish culture-based and enhanced capture fisheries, integrated fish–livestock farming, and wastewater aquaculture (Jana, Mandal and Jayasankar*,* 2018).

Population growth also has the potential to alter fisheries and fishing environments. It is often assumed that numbers of fishers (and hence fishing effort) will increase proportionately with population growth. However, this ignores the ways in which occupations are changing. If we examine the trend of more and more people, including youth, leaving inland capture fisheries due to education and changing aspirations, it would be apparent that demographic factors or overcapacity are not playing a role in declining capture fisheries production.

Nonetheless, concerns about overfishing are frequently identified in the conservation and management literature related to inland capture fisheries (e.g. Vass *et al.,* 2011).

Social and economic development

Social and economic development have been important drivers of change in many inland fisheries. The colonial period was significant in altering the nature of tenure arrangements and emphasizing rent generation as an important aspect of inland fisheries. Productivity, increasing the volume and value of fish and facilitating private investments in fisheries and aquaculture have continued to be important policy objectives, including in the *Pradhan Mantri Matsya Sampada Yojana* and draft National Fisheries Policy of 2020 (Box 10). As the preceding sections have highlighted, the combination of lease arrangements, which generate income for the holder of the management rights and create incentives to maximize the value of fish produced, and stock enhancement and aquaculture technologies, which can increase overall production, has transformed many fisheries. In the first instance there has been increasing intensification and efforts at environmental management levels to maximize production. Peri-urban systems represent examples where water quality and quantity and species composition and stocking density are all managed. However, the result of the increasing control is also that the fishery has changed in nature over time from wild capture to aquaculture in which wild fish have little or no role. While wild capture fisheries can produce fish on an almost daily basis, culture-based fisheries and aquaculture may harvest less frequently, with potential implications both for the availability of fish to consumers and for the fish farmers as there is no continuous income unless they have another source of earnings until the next harvest.

Box 10. Economic development and the transformation of wetland environments

Bengalis have a phrase *Mache bhate Bengali*, or that fish and rice make the Bengali. This phrase highlights both the cultural significance of fish as well as the fact that fish can be an important component of wider food systems. However, the brackishwater parts of West Bengal have witnessed economically driven changes that are modifying the nature of the wetland landscapes and production. Since the 1990s, high returns from India's shrimp exports have created interest in commercial investments in shrimp culture. This was based on the conversion of rice paddies to shrimp farms by flooding them with saline water to create *bheris* that can be stocked with wild-caught shrimp and prawn seed. More recently, brick making has become a lucrative opportunity for local businesses. These use clay from the converted rice paddies and have led to the decline of shrimp culture.

Wetland in West Bengal featuring prawn bheris *in the foreground and brick kilns in the background*

Photo credit: Robert Arthur.

Conversions of rice paddies to shrimp and prawn farms and the subsequent reclamation of old shrimp culture farms by brick kilns have been recognized as major environmental issues in the lower Gangetic Plains and Sundarbans delta region in West Bengal (CSE, 2012; Dutta and Basu, 2016). Wetlands that were once producing the fish and rice that "make the Bengali" now produce shrimp and bricks. The illegal nature of many conversions made both shrimp and brick sectors emerging in the last two decades 'criminal economies', like sand mining (Rudra, 2011). From a governance point of view, these changes severely threaten rural fishing and farming communities by trapping them in arrangements that create modern bonded labour, webs of indebtedness and crime.

Increasing production from inland fisheries through more widespread or intensive stocking has faced challenges including the availability of fish seed, limitations in extension, communication and training capacity, and limited fish disease surveillance (e.g. Kumar, Joshi and Katiha, 2003; Chandra, 2012; Das, 2002; Das *et al.,* 2018). At the same time, attention has also been given to increasing the value of fish produced by targeting higher value markets, branding or certification (Government of India, 2019b). State policies are typically attempting greater market integration under new schemes (Wakamatsu and Wakamatsu, 2017). Currently inland fisheries are under-represented in certification schemes. In India, the Ashtamudi Lake (Kerala) short-necked clam (*Marcia* sp.) fishery is the only inland fishery in India to have been certified by the Marine Stewardship Council to date (Ponte, 2012; Le Manach *et al.,* 2020). How branding and certification will deliver equitable, socially just, ecologically sustainable and ethical fisheries remains to be seen (Lam and Pitcher, 2012).

A tension exists with inland fisheries in terms of how they deliver on socio-economic welfare or on maximizing revenues and profits. The focus on increasing production volumes and values primarily benefits the management rights holder and the lessee, with the fishers frequently employed to guard and harvest the fish. The operation of the lease arrangements, particularly where they are granted to private concerns, can contribute to the economic marginalization of fishers and exclusion from fisheries. Caste-based or identity-based prioritization of access routinely results in difficult contestations and caste-based politics. For instance, while most state legislation prioritizes access for ′traditional fishers′, becoming recognized as traditional can be open to self-identification and political manipulations (Kelkar, 2018). Essentially, traditional identity remains a grey space with stable legal definitions unlikely to be arrived at by both the state and fishing communities.

The marginalization and exclusion of fishers associated with these systems can create a need for alternative livelihoods. Environmental degradation associated with economic development can also contribute to this. Pandit *et al.* (2019) reported that fishers on the Hooghly River had increasingly diversified their livelihoods because fishing *per se* was unable to support the entire household needs of fishers. Thus fishers have been organized in effective cooperatives and have been able to secure access and develop additional activities, for example the Odisha Government's *Matshyajibi Unnayana Yojana* (MUY) programme.

Overall, many inland fishers in India also remain socially marginalized and every effort to improve this situation is important (Katiha *et al.,* 2017). There are gaps in insurance and relief schemes available to fishers and insurance and disaster-relief schemes need to be expanded in coverage and suitability (Parappurathu *et al.,* 2017). For example, insurance companies often require annual payments and do not agree to premiums paid on quarterly time scales, which are usually more affordable for many fishers. Furthermore, many inland fishers, especially those in capture fisheries, cannot access social security schemes related to disability, medical aid or loss of life. In recent instances of extreme flood events, e.g. in Assam where floods in July 2019 led to severe damage to small-scale fish farms, disaster-relief insurance provisions to fishers were poor.

Socio-economic shocks

In addition to the longer-term stresses that climate change and population growth can induce, there are also short-term shocks, such as economic recessions and natural disasters. These can have far-reaching implications for inland fisheries. Fishers in open water environments may be more vulnerable to these natural and human-induced disasters, for example flooding, dam collapses, vessel accidents or oil spills, because fishers work on or are close to the water. As this review was being prepared, the world was affected by the Covid-19 pandemic that has had far reaching impacts across the economy and livelihoods of India (Sunny *et al.,* 2021). The nationwide lockdown from March to June 2020 in India affected fish trade and transportation to distant markets, leading to depressed fish sales and increased fisher unemployment. Within the fisheries sector, the impacts were greater for the more intensive forms of culture-based fisheries and aquaculture. Together with coastal and marine fisheries, these fisheries depend on labourers from inland Northern and Eastern India and these labourers were unable to travel. In addition to the effects on fish production, this also led to increased unemployment in transport, logistics and postharvest activities. Given the nature of the lease arrangements that exist in many fisheries, there are also indications that the impacts of the lockdown may result in increased indebtedness to local moneylenders among fishers and traders, especially in Eastern India.

Small-scale inland capture and culture-based fisheries appear to have suffered less. This finding is supported by news media reports and personal observations throughout this period and appears to be due to the shorter supply chains and ability to alter daily fishing effort. They were also aided by the fact that most states declared fish and fish products as an essential service by mid-April 2020, which helped resume local sales and some transportation to markets. Inland fishers were more able than marine fishers to take advantage of social welfare measures, including rations and grants, and make use of insurance and short-term employment opportunities under the *Pradhan Mantri Garib Kalyan Yojana* (PMGKY) and Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA).

The crucial exemption of fish sales from lockdown restrictions came after appeals from many fishers' forums and NGOs to highlight that people in many regions were as dependent on fish in their diets as they were on milk or vegetables. With sales options for fresh fish limited, fishers also sought to sell dried and fermented fish to sustain their incomes. In states with significant marine and inland capture fisheries, e.g. Kerala, Goa and West Bengal, it appears that inland fish production may have compensated for some of the losses experienced by marine fisheries and the resulting scarcity of fish in markets. However, in other states, fishing was generally perceived to be badly hit, e.g. in Karnataka and Odisha. Pinder *et al.* (2020) have suggested that due to the near-total restriction on sea fishing, there has been increased pressure on inland fisheries and this means that some threatened freshwater fish species such as mahseer may have faced additional impacts during the lockdown.

Summary

A range of drivers has been identified that can affect fisheries. Many of these drivers lead to intensification of culture-based fisheries and the degradation of aquatic environments. While aquaculture and culture-based fisheries are examples of 'climate-smart' food production, experience suggests that both aquaculture and culture-based fisheries can lead to enclosure of fishing environments and loss of access rights. In combination, the various drivers can contribute to the commercialization of inland fisheries, expansion of aquaculture and marginalization of capture fishers. At the same time, the effect of short-term shocks indicates that while inland fisheries may be vulnerable, the experience with Covid-19 has indicated that small-scale fisheries are often linked to local food systems and hence may be more resilient and adaptive. The general insight from the fishers on the pandemic restrictions suggests that small-scale inland capture fishers might have coped better than marine capture fishers or aquaculture farmers involved in large-scale and lengthy supply chains. This has key implications for recognizing the importance of customary tenure arrangements in adapting to shocks and stresses in times of such crises.

The focus on economic development and the creation of a 'Blue Economy' in national and state policy reinforces the trend of increasing productivity and economic efficiency within the sector and may also increase the risk of wider environmental degradation that impacts the sector. This also has implications for the research agendas and the activities of the scientific organizations that support inland fisheries and aquaculture, where they may be focused on a combination of technologies, procedures and guidelines for maximizing productivity of culture-based fisheries and aquaculture and the mitigation of the impacts of economic development on wild fish, for example developing appropriate fish passes. Again, the risk is that wild capture fisheries are marginalized within the agendas and activities of these agencies. Future policy and research will need to engage with the implications of these drivers for small-scale fisheries in particular. In the next section the implications of the current context to objectives of strengthening tenure of small-scale fisheries will be discussed.

DISCUSSION

Inland fisheries and aquaculture in India take place in a wide range of fishing environments, from upland streams through cold-water lakes to large rivers and reservoirs, floodplains, peri-urban wetlands and river deltas. While there are many fisheries that are based on the capture of wild fish, there has been an increasing trend to intensify fisheries through stocking to create culture-based fisheries or aquaculture systems. In some large reservoirs, all three types of fisheries may be found operating at the same time. Because wild capture fisheries have played important roles in the livelihoods of many people in India, it is important to consider how the benefits are derived, the tenure arrangements that govern this and how these might be changing because of changes in policies, society and fisheries technologies.

Tenure refers to the relationships that individuals and groups hold with respect to the environment and natural resources. These can be defined under formal law, customary law or traditional practice and sets of rights and responsibilities can be established concerning who can benefit, in what ways, under what conditions and for how long. Tenure can also establish whether any rights can be transferred and under what conditions. Tenure arrangements are dynamic and are affected by the actions of groups and individuals who seek to make claims on rights, both formally and informally. Thus there can be a range of actors who may be involved and who can draw on different sources of authority to legitimize their claims, including the state, religious bodies, kinship networks and communities.

In customary tenure arrangements, rights are often derived from being a fisher, part of a fishing household or fishing community. In contrast to much of state regulation, the rules that are developed tend to be concerned with ensuring that people can access fish and fisheries and, as such, the emphasis is on constraining individual rights. Thus there are rotational access arrangements, rules that allow the use of small-scale gears to ensure that subsistence fishers can meet their needs, or ′set aside′ schemes where those who fish provide some fish for vulnerable members of the community and those who have done community work. It is important to recognize that these tenure arrangements are not necessarily developed to be egalitarian, rather the emphasis is on welfare and recognizing a right to food, ensuring that people are able to meet their fundamental requirements for survival.

These customary tenure arrangements have evolved with changing environmental and social conditions and been developed based on traditional knowledge. Fisheries households are characterized by a high level of complexity and dynamism and within fishing communities there may be differing interests that need to be negotiated (Kelkar, 2018; Arthur, Friend and Béné, 2016). Furthermore, as livelihood strategies change over time these interests may also change. This applies not just to the regulation of fishing but also to postharvest activities. Customary tenure arrangements can recognize the roles and contributions of fish to local food systems with additional regulation of postharvest activities. For example, traditional processing methods and restrictions on consumption also help ensure equitability and contribute to food safety and consumption regulated through food taboos (Konduru and Kundargi, 2019). The tenure arrangements associated with small-scale inland capture fisheries and the local food systems they contribute to are thus often embedded and developed within local environmental and socio-economic contexts. While customary tenure arrangements and local food systems often inherently consider issues of social equity and can be resilient to social or ecological shocks, they are also vulnerable to external social, economic and political pressures that can transform the arrangements and, consequently, who benefits and how.

While many local communities have managed their fisheries using customary tenure arrangements, the lack of recognition of these tenure arrangements and political transformation through colonialization has undermined or replaced many of them. The legacy of colonial administration combined with the current emphasis on an agenda of economic development favours leasing arrangements. These arrangements can provide benefits to both the holder of the management rights (through lease fees) and the holder of access rights (through income generated from fish sales). These arrangements have become commonplace across fisheries in India and, while diverse in terms of the specific rights that are transferred, serve to create incentives to increase fisheries productivity and to commercialize fish production. Stocking of waterbodies by the leaser can increase the perceived value of the waterbody and therefore increase the amount that may be bid for the access rights. Where the lease provides the lessee with the right to stock, this can also affect the perceived value in similar ways.

Stocking transforms the productive nature of the fishery environment from wild capture fisheries, based on natural cycles and productivity, to the more interventionist capture-based aquaculture, culture-based fisheries or culture-based aquaculture. The combination of an economic development policy agenda, leasing and availability of culture technologies combine to represent a critical driver of the transformation of inland fisheries in terms of ecological, social and economic dimensions. Through these transformations, wild fish stocks and habitats may be degraded and altered to favour cultured species, and fishers may risk becoming contract labourers employed to harvest cultured fish, instead of active, practising and knowledgeable fishers. Thus both the nature of the environment and fishing identities and relationships are reshaped through these processes of change (Kelkar, 2018). Habitat fragmentation and the degradation of wild fisheries, which result from the direct and indirect effects of wider economic development activities outside the fisheries sector, create additional pressures to transform inland fisheries in similar ways.

The extent to which inland fisheries production can be intensified does depend to some extent on the nature of the fishing environment. In open water environments such as rivers and deltas, the connected nature of these environments makes stocking less appropriate. However, if the environment becomes fragmented, e.g. through damming for hydroelectricity or irrigation, then this can change as the resulting closed or semi-enclosed reservoirs and canals are more appropriate for culture-based fisheries and aquaculture.

The ongoing transformation of inland fisheries in India represents dynamic processes of creation, contestation and negotiation. There are also implications for what is produced and how. The emerging culture-based production can be contrasted with the capture fisheries that typically operate at the local level and are characterized by a higher degree of subsistence-oriented production. Intensification and the costs involved in leasing and culturing fish mean changing marketing arrangements to target higher value markets directly or through intermediaries. The relationship with the environment also changes as the focus shifts towards intensification and increased production efficiency. Capture fisheries risk becoming confined to open waters, marginal and less productive environments. The economic marginality of capture fisheries can result from their relative neglect in national and state policy. Where that is the case, they also risk becoming a more acceptable cost of wider economic development (Friend, Arthur and Keskinen, 2009).

While these transformations are ongoing, fishers are not passive but are reacting to changing circumstances. In some cases, they are having to exit capture fisheries, especially along rivers. As such, the prospects of involving fishers in larger social or environmental movements to demand their rights also diminish, a key difference between the organization of marine and inland fishers (Sinha, 2014). In other cases, fishers are organizing to seek to maintain access, engaging on everyday terms with the conflicts and challenges associated with new policies and socio-economic changes (Barman, 2008; Sharma *et al.,* 2010, 2013; Gogoi *et al.,* 2015; Paul and Chakraborty, 2016; Kelkar, 2018). Yet they do so from a relatively weak position as their interests effectively represent an obstacle to the agenda of economic development. Furthermore, the opportunities that leasing arrangements provide mean that there are relatively powerful commercial actors whose interests are legitimized by the economic development agenda.

Responsible governance and subsidiarity considerations mean that the rights of the poor and marginalized should be prioritized over and above larger and more powerful players. The global momentum for addressing governance issues and supporting small-scale fisheries was expressed at the 2008 Global Conference on Small-Scale Fisheries in Thailand. There, the agenda was framed in terms of three priority issues: securing sustainable resource use and access rights; securing postharvest benefits; and securing social, economic and human rights. This framed the process through which the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (FAO, 2014) were created and endorsed and responsible governance of tenure is a key component of the SSF Guidelines. This is supported by other platforms, including the 1995 Code of Conduct for Responsible Fisheries, which called for states to protect the rights of fishers and fishworkers who contribute to subsistence, artisanal, or small-scale fisheries; the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (the VGGT, FAO, 2013b); the Voluntary Guidelines on the Progressive Realization of the Right to Adequate Food in the Context of National Food Security (FAO, 2005); and the Principles for Responsible Investment in Agriculture and Food Systems (CFS-RAI).

In contrast with the NIFAP that had called for plural and participatory decision-making processes, the draft national fisheries policy does not adequately address important aspects of inland fisheries, including gender, caste and class. Furthermore, local governance structures and traditional practices have been overlooked in favour of a one-size-fits-all approach for the economic development and intensification of inland fisheries. Recognizing and honouring the rights of fishers to participate in management of inland capture and culture-based fisheries is a policy gap in India. Participation rights can help make the voices of fishers and fishworkers heard in all discussions pertaining to management of fisheries (NPSSFI, 2019a,b). In that respect, the right to participate in cooperative management models needs to be explored (Tyagi, Bisht and Pal, 2015).

In addition to the human dimension of inland fisheries, environmental health needs to become a major priority for inland fisheries management. Management and access rights need to be accompanied with responsibilities towards the environment (Zheng, 2018). This includes decisions taken by the state or others holding the management rights regarding fishing capacity or the claiming of other rights, for example fishers claiming the right to mine sand. Harvesting and managing fish resources, including wild or cultured fish, habitat alteration and sand mining, can all impact the aquatic environment. These activities therefore involve a responsibility towards conserving the biological, ecological, genetic, aesthetic, landscape and abiotic aspects of the environment. A principle of the SSF Guidelines is to guard against undesirable outcomes, including overexploitation and negative environmental, social and economic impacts (FAO, 2014). This requires therefore that those holding rights should practise responsible conduct towards the environment and promote community solidarity, enabling people to meet their basic needs. It is also reflected in the calls for an Ecosystem Approach to Fisheries Management (EAFm) that is explicitly referred to in the new fisheries policy. Yet the potential to realize EAFm is limited in situations where rights and tenure remain insecure even as aquatic environments continue to be degraded, undermining both human well-being and ecological sustainability. Realizing EAFm in the inland fisheries of India requires that the issue of rights and tenure be addressed to ensure that the ecological sustainability and social and economic contributions of the fisheries are not put at risk.

Within the new fisheries policy, strengthening of tenure is presented in terms of longer duration leases. While this does provide the lessee with more secure access, these are often implemented by more powerful commercial operators. Nor does this approach address the employment conditions of fishers or the appropriateness of leasing arrangements in all fishing environments. Given the incentives that leasing creates for inland fisheries, there are also risks that it does not provide for more sustainable management but instead more intensification. There are other aspects of tenure that should be prioritized. The principle of subsidiarity (ICSF, 2014) focuses on bottom-up processes to ensure the well-being of small-scale fishworkers. Subsidiarity considerations also mean that the rights of the poor and marginalized are prioritized over and above larger and more powerful players. For instance, penalties for non-compliance of environmental and resource management guidelines could be applied in direct proportionality to the socio-economic status of violators, with dominant parties penalized to a greater extent than weaker parties (NPSSFI, 2019a,b).

It is important also to look beyond the rights associated with fisheries management and fishing. Additionally, governance rights, rights to economic empowerment and finance, cultural rights, and rights to infrastructure, technology and information, can also be attached to tenure and rights (Sharma, 2011; NPSSFI, 2019). These can all contribute to secure fishers and fishworkers from various threats, e.g. the eviction of small vendors from urban marketplaces, indebtedness, rent-seeking or usurping by contractors or moneylenders, lack of basic amenities and transport facilities, limited technological access, right to sanitation and hygienic conditions, amenities (e.g. fish landing sites, markets, storage and transport), ancillary income generation options, agri-credit schemes and loan facilities (NPSSFI, 2019a,b). Thus the key question is not whether leases should be extended but how human rights, particularly for the vulnerable and marginalized within fishing communities, can be linked to management and access rights, and how these rights are identified and demarcated (Allison and Badjeck, 2004; Allison *et al.,* 2012).

The transformation of inland fisheries in India therefore has implications for research agendas and scientific enquiry. Research priorities, as framed by the new fisheries policy, are currently focused on the one hand on technologies to increase fisheries productivity, such as new strains, marketing arrangements and

certification schemes that can enhance productivity and the value of the fish produced. On the other hand, they are focused on identifying measures that can address the environmental consequences of economic development and fisheries intensification, for example, developing fish passage and aquaculture technologies to compensate for degraded fishing environments and wild capture fisheries or techniques to mitigate pollution and to address disease and pathogens associated with intensive culture. In many cases, there is little or no role for the traditional knowledge of fishers and fishworkers and little analysis of activities beyond fish production.

Less attention is given to identifying and enhancing the important and multidimensional contributions that wild capture fisheries in inland waters can make to addressing poverty and vulnerability and to the critical role of nature and functioning of customary arrangements in this. There is a need for a research agenda that can examine the social, cultural and economic benefits that are provided by inland capture fisheries and implications of the ongoing transformation for this. This would require indicators of performance beyond volume and value of fish and to explore the dynamic political economy of inland fisheries, including aspects of power relations and power dynamics. The NIFAP underscored the importance of state control and intervention in resolving such contestations but needs to acknowledge more the importance of reviving and restoring local knowledge systems and participatory mechanisms for dialogue between interest groups.

CONCLUSIONS

This review has summarized some of the key elements of the vast, diverse and complex inland fisheries that are found in India. The objective has been to highlight how inland fisheries have been changing and the challenges that this presents for governance and tenure. Inland fisheries have been, and continue to be, transformed through leasing arrangements, changes to the natural environment, including the creation of new aquatic habitats, and the widespread practice of stocking waterbodies. This transformation has occurred to the extent that, for many policy-makers, scientists and practitioners, inland fisheries have essentially become synonymous with freshwater aquaculture or culture-based fisheries. Despite concerted efforts towards cooperative and community-based management, state control and private ownership of property in inland capture and culture-based fisheries remain the dominant arrangements and the focus of the emerging national policy and legislation on fisheries.

This focus on intensification of inland fisheries overlooks the role of wild capture fisheries and the degradation of fishing environments that is occurring across the country. Important issues concerning the trade-offs between economic efficiency, intensive production and revenue yields from aquaculture and culture-based fisheries on the one hand, and the priorities of nutrition, rural food security, poverty alleviation, and livelihood dependency on capture fisheries on the other are highlighted. While culture-based fisheries and aquaculture may have a great deal of potential from a fish production perspective, there are important environmental and social dimensions that must not be overlooked. The resilience and adaptive flexibility of inland capture and culture-based fisheries becomes evident in the face of systemic shocks like the Covid-19 pandemic, where inland small-scale fishers could meet their subsistence needs better than the large-scale, structured arrangements of trade-oriented fish production.

Attention turns to how these two diverging components can be reconciled for ecological sustainability and socio-economic equity and thus draws attention to issues concerning fishers' rights, tenure and human rights as well as to the responsibilities of management and access for rights holders. Two key issues become apparent. Firstly, given the diversity of fishing environments and livelihood strategies, as well as the evidence of conflict around leasing arrangements, one size clearly does not fit all when it comes to tenure arrangements. There is a need to understand the specific characteristics of the fishing environments and of those dependent on the fisheries as a basis for developing appropriate tenure arrangements. Secondly, there are clear differences in the outcomes and benefits from fisheries sought by different actors. As customary tenure arrangements show, there can be a need to compromise or trade off optimization to achieve multiple valued outcomes. Exploring prospects for recognizing or reviving customary tenure arrangements could represent a way to address these two issues. It is evident that we need to go beyond technical and economic–institutional rationalities and explore cultural, social and political grounds to do so. For this, conflicted ideas and contested interactions of fishing groups over space, ecology, ideas and definitions of overfishing, tradition, justice, equity, caste, gender and class must be thoroughly engaged with and addressed.

The review also identifies examples across India that represent potentially enabling and constraining conditions to secure human rights as well as tenurial rights and access in inland capture fisheries and aquaculture. It also highlights the major challenges that impinge on these objectives: severe water pollution, economic aspirations and development, conflicting government mandates (e.g. biodiversity conservation and fisheries development), health risks and changing identity politics, being some of them. These challenges also imply that rights-based discourses cannot exist in isolation from environmental realities. For instance, as inland capture and culture-based fisheries grow in quantity, can the quality of fish be assured with pollution and health risks minimized? Can caste politics become an enabling force for marginalized fishing communities, or will it instead distance fishers from their traditional spaces and render arguments for fishing rights irrelevant? How do we address these contradictions to manage the multiple normative objectives of inland capture fisheries and aquaculture? What should be the balance between formal structures of governance and spaces to revive or create community-based tenure and management systems? Such questions, while challenging, must be embraced for further discussions, and to support the action needed for the meaningful and sustainable development of inland fisheries in India.

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GLOSSARY

A glossary of terminologies related to inland waterbodies with significant capture and culture-based fisheries. Terms with vernacular origins are italicized.

Backwaters: Waterbodies along coastal and estuarine areas, typically with dominance of freshwater influx but also marine inputs, e.g. the backwaters of Kerala. The term is also used for river waters impounded upstream of a barrage or dam, e.g. the backwaters of the Harike Barrage in Punjab.

Barrage: A gated dam-like structure placed in a watercourse to increase the depth of water or to divert it into a channel for navigation or irrigation.

Beels: Shallow floodplain wetlands with ample macrophyte vegetation; the term is used in regions of Bengal and Assam's river floodplains.

Brackishwater lagoons: Large waterbodies formed by the influx of coastal saltwater into land-enclosed areas, where the mix of saltwater and freshwater creates brackishwater conditions with moderate salinity, and creates highly productive conditions for diverse fish species, e.g. Chilika Lagoon, Odisha.

Braided river channels: Channels where a river channel splits into more than one branch due to the formation of large mid-channel sand bars or point bars, e.g. the Gandak River in Bihar is highly braided.

Cold-water lakes: Natural (or sometimes human-made) lakes in very cold regions, e.g. Tso Moriri Lake of Ladakh.

Deltas: Regions with massive alluvial deposition by large rivers where they meet the sea, e.g. the deltas of the Ganga–Brahmaputra, Godavari, Kaveri rivers and so forth.

Estuaries: The part of the river affected by the tide, creating conditions suitable for freshwater as well as saltwater fish and shrimp species.

Farm ponds: Human-made ponds created in or adjoining farmlands for water storage and small-scale irrigation, but often used for small-scale aquaculture as well.

Feeder canals or feeders: Human-made canals diverting water from one dam or barrage to another, or from a barrage to a river, e.g. the Farakka feeder canal diverts water from the Ganga to the Hooghly distributary.

Floodplains: Sediment deposits (composed of silt and sand) forming large plain regions along perennial rivers. They are formed and maintained by strong seasonal flooding.

Haors: Like *mouns* but filling up mostly during the monsoons and then being waterless but full of moisture in the dry season.

Hill streams: Small seasonal and perennial streams flowing through hilly regions, often with steep gradients but minor and seasonal discharge.

Irrigation canals: Human-made canals constructed to divert river water from dam reservoirs to the 'command areas' of dams, i.e. the agricultural area intended to receive irrigation water from the dam. Many irrigation canals host some fishing activity.

Khaals: Like *beels* but large enough to have flowing water.

Mangrove forests: Estuarine backwater areas or creeks along which mangrove vegetation (predominantly of the family Rhizophoraceae) grows, e.g. the Sundarbans mangrove forests, mangrove forests along the west coast of Maharashtra, Goa and Kerala.

Mouns: Wetlands or ponds formed in river floodplains due to depressions created by recent subsurface tectonic activity (neo-tectonic), e.g. the *mouns* of North Bihar.

Natural lakes: Deep lakes formed by natural tectonic, meteoritic or geophysical processes. India has very few natural lakes and these are mostly concentrated in the trans-Himalayas (e.g. cold-water lakes), desert regions (saline lakes) and glacially influenced lakes (e.g. in the Himalayas). A meteoritic lake can be found in Lonar, Maharashtra.

Nullahs: Minor streams, gullies or channels forming during the monsoon season and joining a larger wetland, lake or river.

Oxbow lakes: Floodplain lakes or wetlands formed after meandering channels become cut off, following dynamic sediment erosion-deposition processes in large river floodplains. The cut-off meander sections appear curved like the horns of oxen, hence the term 'oxbow lakes'. These waterbodies can be deep, based on the magnitude of river discharge, extent of flooding and sediment flows. Large oxbow lakes are found in the Ganga and Brahmaputra river systems.

Pokhars or *pukurs*: Human-made ponds and tanks in rural Bengal.

Prawn *bheris*: Areas along waterbodies for cultivation of prawns and shrimps (sometimes both), demarcated using bamboo poles, metal frames, nets, etc. These are commonly seen in estuaries and lagoons. This document follows the convention that prawns are Palaemonids, e.g. *Macrobrachium* sp. in freshwater and brackishwater and shrimps are Penaeids, including both brackishwater and marine species.

Reservoirs: Deep-water areas impounded behind (upstream) a dam or barrage.

Saline lakes: Inland lakes that hold saltwater, generally due to mineral salt accumulation that often occurs as the lakes tend to be endorheic (i.e. without any outlet). They include both desert and cold-water lakes, e.g. Sambhar Lake in Rajasthan.

Tanks: Human-made waterbodies to store water, mainly for human use. Often called 'lakes' in common usage.

Tidal rivers: River channels influenced by tidal action, showing diurnal and subdiurnal fluctuations in water level according to tidal phases, e.g. the Hooghly River.

Wastewater aquaculture ponds: They use wastewater as a fertilizer to increase the productivity of the pond by increasing the quantity of plankton and benthic invertebrates that fish feed upon.

Wetlands: Shallow waterbodies holding water for all or most of the year. A generic term for natural as well as human-made ponds, lakes and lagoons with abundant vegetation.

ISBN 978-92-5-135762-0 ISSN 2070-6065

CB8615EN/1/03.22