RIVER CONSERVATION IN THE INDIAN HIMALAYAN REGION

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King's College London

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by

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A thesis submitted in partial fulfilment of the requirements for the degree of

PhD

University of London

2014

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ABSTRACT

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Abstract

Rivers have a multitude of important functions and provide crucial services to millions of people. However, rivers currently face severe anthropogenic threats due to an expanding human population and a surge in water demand. The fish species present within rivers provide a source of protein to some poorer sections of communities and present ecological and socio-economic opportunities for various stakeholders, (i.e. village members, catch-and-release (C&R) angling associations, C&R anglers, forest managers, and conservationists). To protect rivers and their fish species in the Indian Himalayan region, critical stressors and novel conservation strategies were investigated. Terrestrial Protected Areas (tPAs) are applied management tools for biodiversity conservation in the region, and along with existing managed reaches, (i.e. temple pools and angling pools) could protect river ecosystems from pressures such as over fishing, habitat degradation and fragmentation, and pollution. Although under scrutiny for its probable effects on aquatic ecosystems, C&R angling as a leisure activity could protect target

fish species through associated socio-economic opportunities, and could act as a monitoring tool for fish species. A global online survey conducted among C&R anglers visiting Indian rivers revealed their willingness to assist with conservation projects targeting prime angling fish species. In view of the current benefits associated with global flagship species and examined support among local stakeholders in the study area, an attempt was made to promote a freshwater fish as a flagship conservation species for wider benefits to river ecosystems. With the present available support among local stakeholders and novel applicable conservation opportunities for river ecosystems, an innovative strategy, i.e. setting up of Freshwater Fish Safe Zones (FFSZs) was proposed to the State and Central Government of India to bring about long-term ecological and socio-economic benefits to Indian rivers and local stakeholders.

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Acknowledgements

This thesis would not have been completed without the constant leadership and direction of numerous people. I would like to first and foremost thank my supervisor, Dr Michael Chadwick at the Department of Geography, King's College London, UK for his guidance and support throughout the course of my PhD. This educational journey would not have been completed without his help. I am also thankful to Prof Nick Drake and Dr Jamie Lorimer who were very patient with me during my PhD. I am grateful to Dr Robert Francis for his valuable comments. The financial assistances provided by the King's Continuation Scholarship, the School of Social Science & Public Policy (SSPP) research student small bursaries, and the Geography Department small grants funds have played significant roles towards the numerous field trips I have undertaken to the Indian Himalayan region, and the completion of this thesis. Both my Indian supervisors, Dr V.B. Mathur and Dr K. Sivakumar at the Wildlife Institute of India, Dehradun have assisted me greatly in carrying out successful fieldworks, and have always provided valuable comments and suggestions throughout my PhD. I would like to sincerely thank Dr Rajeev Raghavan, Prof Prakash Nautiyal, Mr Adrian Pinder, Prof Atul Borgohain, Dr Neelesh Dahanukar, Parineeta Dandekar, Dr Arun Kanagavel, Shannon Bower, Prof Andy Danylchuk and Prof Steven Cooke for their valuable contributions. I am thankful to the Chief Wildlife Warden, Government of Uttarakhand, India for granting me the permission to undertake my fieldworks. I would like to acknowledge the Directors and DFOs of Corbett Tiger Reserve and Rajaji National Park for their assistance

during my numerous fieldworks. Mr. Sumantha Ghosh helped me tremendously during my field study, and I cannot thank him enough. I am also grateful to Mr Misty Dhillon for his advice and help during my PhD. I am thankful to the Assam (Bhoralli) Angling and Conservation Association for providing me with important data, and the numerous catch-and-release anglers who voluntarily participated in my online survey. The field assistants Vinod Belwal and Sanjeev Paroriya have been absolutely indispensable during the numerous field works. Vinod often went to great lengths with me to ensure that the desired field sites were sampled on time. Many of my friends have provided crucial encouragement throughout my PhD years. In particular, I cannot thank Dr Seon Young Lee enough for her timely advice and suggestion throughout my time at King's. I also thank Navneet Singh for her assistance during my PhD. Finally, I would like to thank my parents who have believed in and supported me all these years. Last, but not the least, I am forever indebted to Tanvi Gore for being my continuous pillar of strength.

Nishikant Gupta

June, 2014

Chapter 1

Introduction

1.1. Background

Rivers have a multitude of key ecological and societal functions (Fitzsimons and Robertson, 2005; Sarkar et al., 2008). They are vital for soil fertility maintenance, transportation, forest resources development, wildlife conservation (Suthar et al., 2010), cater to the industrial, agricultural and domestic sectors (Solaraj et al., 2010), and contain numerous fish species (Shahnawaz et al., 2010). However, major rivers such as the Nile, the Ganges, the Amu Dar'ya and Syr Dar'ya, the Yellow River, and the Colorado River are all facing various levels of anthropogenic stressors (Saunders et al., 2002).

The pressure from a growing population and subsequent urbanization has led to a surge in water demand (Ahmad and Rawat, 1990; Saunders et al., 2002; Le Pichon et al., 2006; Sarkar et al., 2008; Atkore et al., 2011; Everard and Kataria, 2011; Pinder and Raghavan, 2013). There is overexploitation of river resources, water pollution (point and non-point source), flow modification in the form of obstructions and dams, destruction and degradation of riparian habitats due to an increase demand of land for agricultural and urbanization purposes, and invasion of exotic fish species (Kumar, 2000; Cambray, 2003; Collares-Pereira and Cowx, 2004; Suski and

Cooke, 2007; Lakra et al., 2007; Jena and Gopalakrishnan, 2012). Additionally, environmental changes such as global warming and shifts in precipitation patterns are also playing crucial roles in imperilling rivers and their fish diversity (Dudgeon et al., 2006; Nguyen and Silva, 2006; Nel et al., 2009b).

Freshwater fish species are vital components of river ecosystems, i.e. they control the trophic structures affecting the distribution of nutrients, some occur at the peak of food webs as apex predators, and others are used as indicators of riverine health (Singh and Sharma, 1998; Kumar, 2000; Schindler, 2007). Importantly, fish species have now become a focus of attention, and one of the reasons is that they are a crucial and sometimes the only source of protein for some poorer sections of societies especially in developing countries (Duncan and Lockwood, 2001; Nguyen and Silva, 2006; Lakra et al., 2007). However, similar to rivers, freshwater fishes too are under threat (Sarkar et al., 2008). So much so, that they are not only the most threatened group of vertebrates after amphibians (Bruton, 1995), but have extinction rates five times greater than that of terrestrial animals, and three times than that of coastal marine mammals (Ricciardi and Rasmussen, 1999; Saunders et al., 2002; Sarkar et al., 2008). In view of the above, there is a need to protect rivers and their fish species (Bowen-Jones and Entwistle, 2002; Farjon et al., 2004; Barua et al., 2012).

With 3% of the world's area and about 17% of the world's population, India has 8% of globally recorded floral and faunal species (Ministry of Environment and Forests, 2010). The country also comprises of ten biogeographic zones, defined as 'a geographic region that has similar

environmental conditions and is capable of harbouring the same type of biota with similar life strategies and adaptations (Sinha et al., 2009). These zones are the Desert, Semi-Arid, Western Ghats, Deccan Peninsula, Gangetic Plain, Coasts, North-East, Islands, Trans-Himalayas and the Himalayas (Sinha et al., 2009) (see Appendices I and II). India is blessed with many perennial rivers (Mall et al., 2006; Mishra et al., 2009), and these harbour abundant fish species (Shahnawaz et al., 2010).

The Himalayan region (28°N & 36°N, 72°E & 96°E) is one of the biodiversity hotspots of India, is situated at the junction of the Palaearctic, the Africo-tropical, and the Indo-Malayan realms, and characterized by an agro-pastoral economy (Badola and Hussain, 2003). With an area of over 2, 36,000 km^2, the Himalayan region covers 18% of India's land surface, and contains 6% of its population. This zone has distinct regions based on elevation (Kumar et al., 2012). For example, up to an altitude of 1,000 m land cover is tropical sub-humid sal forests (*Shorea robusta*). At elevations of 1,500 m to 3,000 m there is a dominance of chir pine (*Pinus roxburghii*). The valleys are covered by montane forests and alpine grasslands. Evergreen oak forests consisting of brown oak (*Quercus semecarpifolia*), moru oak (*Q. dilatata*) and grey oak (*Q. leucotrichophora*) alternate with areas dominated by conifers, e.g. east Himalayan fir (*Abies spectabilis*), Himalayan cypress (*Cupressus torulosa*); deciduous trees such as Nepalese alder (*Alnus nepalensis*) and Himalayan horse chestnut (*Aesculus indica*); or different species of maples (*Acer* spp) (Ramakrishnan, 2003).

The climate varies according to the elevation, e.g. subtropical in the southern foothills, warm temperate in the middle Himalayan valleys, cool temperate in

the higher elevations of the middle Himalayas and alpine climate at higher elevations (Nautiyal and Kaechele, 2009). The region has over 18, 000 plant, 2, 000 avian and 240 mammalian species (Badola and Hussain, 2003; Singh et al., 2011) and encompasses the Indian states and union territories of Jammu and Kashmir (33°27′0″N, 76°14′24″E), Himachal Pradesh (31°6′12″N, 77°10′20″E), Uttarakhand (30°19′48″N, 78°3′36″E), Sikkim (27°19′48″N, 88°37′12″E) and Arunachal Pradesh (27°3′36″N, 93°22′12″E) (Pandit et al., 2006) (see Appendix III).

The Himalayan region provide a continuous supply of water through its multiple glaciers (Pandey et al., 1999), is the source of some of the major river systems in India, and a lifeline for millions of people who depend on these rivers (Bajracharya et al., 2008). The main rivers here are of the Indus and the Ganga-Brahmaputra-Meghna systems. The major tributaries of Indus are Sutlej, Beas, Ravi, Chenab, and Jhelum. The Ganga-Brahmaputra-Meghna tributaries include Bhagirathi and Alaknanda which form the Ganga. The tributaries of Brahmaputra are Subansiri, Jia Bharali, Dhansiri, Puthimari, Pagladiya and Manas. The Barak River, the headwaters of Meghna, rises in the hills in Manipur and its major tributaries are Makku, Trang, Tuivai, Jiri, Sonai, Rukni, Katakhal, Dhaleswari, Langachini, Maduva and Jatinga (Sehgal, 1999) (see Appendix III). Over 250 fish species have been reported in the rivers here (Bhatt et al., 2012). Among these, over 100 fish species are used either as a food source or in the aquarium trade by local communities (Sarkar and Lakra, 2010). In addition, catch-and-release (henceforth C&R) angling for mahseer (*Tor*) fish species has brought socio-economic benefits, (i.e. food source and job opportunities) for some local

stakeholders, i.e. village members and C&R angling associations (Everard and Kataria, 2011).

However, an increase in the region's population (Pandit et al., 2006), rapid expansion of agriculture (Negi et al., 1999), steady rate of deforestation due to the demand for fodder and fuel wood, and recurrent forest fires (Sharma et al., 2008; Kumar et al., 2012), have all resulted in the degradation of this region (Awasthi et al., 2003; Prabhakar et al., 2006; Nandy et al., 2011) (see Appendix IV: photo 1). Additionally, developmental activities such as road cuttings (Sharma, 2003), and heavy rainfall (Pande et al., 2002) have ensued soil erosion leading to wide scale siltation of rivers and devastating floods (Tiwari, 2000; Krishan and Velmurugan, 2009) (see Appendix IV: photo 2).

There is further pressure for rivers here from land use change. For example, between 1965 and 1995 there was a 5% reduction in total forest area and 11% increase in cultivated land in Shail Gad watershed (Tiwari, 2000). Similarly in Balia watershed, there was a 12% decrease in total forest area and 8% increase in cultivated land (Tiwari, 2000). Whereas, there was a 6% decrease in forest areas and 15% increase in cultivated land in the headwaters of the Kosi River between 1965 and 1995 (Tiwari and Joshi, 2005). There is also river habitat destruction through illegal sand and boulder mining (Atkore et al., 2011), and point and non-point sources of pollution, e.g. untreated sewage, industrial effluents and mining wastes reaching the rivers (Pande et al., 2002; Tiwari, 2008; Lakra et al., 2010; Sarkar et al., 2013a,b) (see Appendix IV: photos 3, 4 and 5). The local use of destructive fishing methods such as the use of dynamite and poisons (Tiwari, 2008; Lakra et al., 2010; Atkore et al., 2011; Everard and Kataria, 2011; Sarkar et

al., 2013) (see Appendix IV: photo 6); and the introduction of exotic fish species, e.g. rainbow trout (*Oncorhynchus mykiss*), Atlantic salmon (*Salmo salar*), brown trout (*S. trutta*) and brook trout (*Salvelinus fontinalis*) have played destructive roles for rivers and their fish species (Kumar, 2000; Collares-Pereira and Cowx, 2004; Singh et al., 2010). Over 70 existing barrages or dams (see Appendix IV: photo 7), 300 further planned, and 30 under construction are too threatening the survival of rivers here (Bandyopadhyay, 1995; Shah and Kumar, 2008; Elahi and Sikder, 2010; Pandit and Grumbine, 2012; Sikder and Elahi, 2013).

Further, within 30 years (1970-2000), the dense vegetation cover in the Himalayas has reduced from 36% to 9% (Nautiyal and Kaechele, 2009). Further studies have indicated degradation of broadleaved forests (Wakeel et al., 2005), and forest loss and fragmentation (Pandit et al., 2006). The various Himalayan habitats, (i.e. alpine, montane, western Himalayan, shivaliks and sub-Himalayan, north-eastern hills and temperate belt) are all subjected to degradation and fragmentation (Nautiyal and Kaechele, 2007). The alpine habitat is facing pressures such as overgrazing by livestock, commercial harvest of wild medicinal herbs and uncontrolled tourism (Uniyal et al., 2002). The montane habitat is affected by encroachment for habitation and cultivation (Khan et al., 2013). The western Himalayan region is primarily endangered by slash and burn agriculture (Chandrashekhar et al., 2003). The shivaliks and sub-Himalayan habitat are under severe threat from human encroachment (N. Gupta, personal observations). The north-eastern hills suffer from timber extraction and slash and burn agriculture (Choudhury, 1999; Ramakrishnan and Kushwaha, 2001). The temperate belt is subjected

to cultivation pressures and construction of roads along habitats (Kumar and Bhatt, 2006).

The terrestrial protected areas (henceforth tPAs) of the region (Sinha et al., 2009) have worked towards providing protection and conserving the region's floral and faunal species. However, such legislatively defined areas too have been affected by land use change. For example, the Gangotri National Park (NP henceforth) (31°38′0″N, 79°33′0″E; 1,553 km^2) is facing pressures such as destruction of forests for fuel wood and associated landslides (Bhardwaj et al., 2010). The Govind NP (30°44′0″N, 78°27′0″E; 472.08 km^2) is suffering from land degradation due to high grazing pressure, extraction of medicinal plants and timber collection (Agnihotri et al., 2013; Rawat and Chandra, 2013). The Nanda Devi Biosphere Reserve, i.e. Nanda Devi NP (30°25'7"N, 79°50'59"E; 630.33 km^2) and Valley of Flowers NP (30°44'00"N, 79°38'00"E; 87.50 km^2) are subject to deforestation, collection of endangered plants for medicinal use, forest fires and grazing by livestock (Kandpal and Sathyakumar, 2010). The Corbett NP (29°32′0″N, 78°56′7″E; 520.82 km^2) faces critical threat of land encroachment (see Appendix V). The Rajaji NP (30°3′29″N, 78°10′22″E; 820.42 km^2) is endangered by cattle grazing, summer fires, and collection of fuel wood and fodder near riparian corridors (Joshi, 2010, 2012).

Climate change too continues to have a disturbing effect on the Himalayan Rivers and their fish species (Dhar and Mazumdar, 2009; Kumar and Chopra, 2009). India's greenhouse gas emission is increasing (Asokan and Dutta, 2008), and a temperature rise between 3.5 to 5.5°C predicted by the year 2100 (Kumar and Chopra, 2009) can give rise to more devastating

floods due to rapid glacial melt (Bajracharya et al., 2008). The shrinking of the Himalayan glaciers (Kumar, 2005) could also lead to a decrease in water flow of the perennial rivers impacting millions of people dependent on them (Kumar and Chopra, 2009). Summing up, Indian Himalayan Rivers and their fish species are facing critical pressures (Gaston et al., 1983; Singh and Singh, 1987; Kala et al., 2002; Pande et al., 2002; Nautiyal et al., 2004; Tiwari, 2008; Nautiyal and Kaechele, 2009; Lakra et al., 2010; Sarkar et al., 2013), and urgently require the application of management strategies for their immediate protection and long-term conservation.

1.1 Potential conservation strategies and management tools for protecting rivers and their fish species

With the current threats being faced by the rivers and their fish species in the Himalayan region, there is a requirement of additional safeguarding mechanisms to protect and conserve the rivers here. Although multiple, regionally-based, non-governmental organizations such as the Corbett Foundation, the Mahseer Conservancy, Pragya (India), Centre for Environment Education (CEE Himalaya) and the Himalayan Outback are playing important ecological and socio-economic roles at the grass root level; there is a need to investigate additional novel strategies to assist these and other government and non-government organizations in order to sustain long-term benefits from river ecosystems.

1.2.1 Terrestrial protected areas (tPAs) and river ecosystems

Past literature has suggested that protected areas (henceforth PAs) have the potential to assist rivers from negative stressors, and improve fish biodiversity (Keith, 2000; Saunders et al., 2002; Sarkar et al., 2008; Atkore et al., 2011; Abraham and Kelkar, 2012; Sarkar et al., 2013). In addition, the adequate representation of river systems in PAs has been suggested to offset various anthropogenic threats (Nel et al., 2007, 2009). Some authors have shown high fish population densities, and greater sizes of fish species within PAs in comparison to sites outside PAs (Atkore and Sivakumar, 2011; Abraham and Kelkar, 2012; Sarkar et al., 2013). In the Indian Himalayan region alone, there are over 100 tPAs, (i.e. National Parks and Wildlife Sanctuaries) (Sarkar et al., 2008). Unfortunately, there is poor representation of river ecosystems within such tPAs; and very few studies (Atkore et al., 2011) have been conducted on the role of existing tPAs for river ecosystems. Although often criticised for excluding local village communities and their 'rights to forest', the current tPAs network in the region could have the potential to provide benefits to river ecosystems. Additionally, community-conservation initiatives for river ecosystems bordering current tPAs could see the inclusion of communities within management initiatives, provide socio-economic benefits to local communities, and potentially assist in protecting river ecosystems from harmful stressors (Gupta, 2013). Therefore, it is necessary to examine tPAs in terms of their fish diversity and habitat especially if they encompass perennial rivers within their legislatively defined boundaries.

1.2.2 The role of religion in conserving freshwater fishes

World religions have played an important role in facilitating biodiversity conservation (Bhagwat and Palmer, 2009; Bhagwat et al., 2011). In many countries, local cultures have moulded themselves based on surrounding ecosystems while associated religious beliefs have determined local resource use, and facilitated the protection of species and spaces (Colding and Folke, 1997; Anthwal et al., 2010). Although the adherents of major religions are unequally distributed in relation to areas important for global biodiversity (Mikusiński et al., 2013), many sacred species and sites are concentrated in biodiversity-rich nations. For example, in India, there are probably more sacred sites (informal) than formally protected areas (Kala, 2011; Rutte, 2011). India is home to numerous religions, each with its own beliefs and taboos (Sinha, 1995; Kanagavel et al., 2014) but united by a common passion and care towards nature and one's ecological surroundings. In fact, many species in India receive protection because of their association with religious deities including being revered as vehicles of Gods.

Although freshwater fish are one of the most threatened vertebrate groups (Leidy and Moyle, 1997; Carrizo et al., 2013), they are often neglected for conservation efforts in many parts of the world, including freshwater biodiversity rich countries such as India. Although there are more than 150 threatened freshwater fish species in India (IUCN, 2014) none receive any legal protection, or subjected to species specific conservation plans. The escalating threats to freshwater ecosystems and fish species has been a simmering debate not just among like-minded scientists, but associated

stakeholders too (Gupta et al., 2014a). However, stakeholder involvement for freshwater biodiversity conservation in India is often overlooked by policy makers (Gupta et al., 2014b) due to overt emphasis on centralisation, and adoption of a techno-centric approach to managing ecological entities.

Freshwater fish have been considered as sacred in many parts of India since the Vedic period (1750-500 BC) (Nautiyal, 2014). For example, the mahseer (*Tor* spp), a threatened group of cyprinid fishes (Pinder and Raghavan, 2013), were mentioned in various religious scriptures, being valued for propitiating the souls of the deceased ancestors, and as being relished by the forest-dwelling saints (Nautiyal, 2014). This reverence for the mahseer continues even today, through their protection in river stretches associated with temples (Dandekar, 2011), where fishing is prohibited, and local communities, pilgrims and temple authorities help in monitoring and safeguarding their populations (Figure 1.2.2).

Figure 1.2.2: Temple sanctuaries in a) Walan Kond, b) Yenekkal, c) Ramanathapura and d) Sishila [Images a and b © Parineeta Dandekar; c and d © Shrinivas Kadabagere]

In Walan kond (Savitri River),Western Ghats, locals regard mahseer as the 'children of the goddess, *Varadayani Mata*' (Katwate et al., 2014), a belief that has helped in conservation. The Sringeri fish sanctuary on the Tunga River, also in the Western Ghats protects several fishes, including threatened cyprinids of the genera; *Hypselobarbus*, *Neolissochilus* and *Tor*, while Chippalgudde Matsya Dhama, another sanctuary on the same river, helps protect among other fishes, an endemic herbivorous cyprinid, *Hypselobarbus pulchellus*. The religious sentiments at these two temples are that these fish are the incarnations of Lord Vishnu (the supreme god) and therefore worshipped. Many tributaries of the River Ganges are considered sacred, and religious sentiments play a positive role in the protection of the

endangered golden mahseer (*Tor putitora*) in this region (Dandekar, 2011). The Machchiyal Lake in the state of Himachal Pradesh protects various fish species, and the local worship of the Machendru Devta (Fish God) is the key force driving conservation.

In India, the charismatic and threatened mahseer (*Tor* spp and *Neolissochilus* spp) are probably better protected in such sacred sites, in comparison to unprotected open-access areas, where they are subjected to indiscriminate (often destructive) fishing and habitat loss (Pinder and Raghavan, 2013; Gupta et al., 2014c; Nautiyal, 2014). However, whether religious beliefs can sustain community-based conservation initiatives in changing times is an important question, for which we need to understand how religious beliefs work to maintain social institutions such as sacred sites.

Religion is a powerful facilitator for the evolution of pro-social behavior in humans (Norenzayan and Shariff, 2008). Two hypotheses have been suggested to explain the apparent promotion and maintenance of beneficial traits through religious beliefs. The first, supernatural monitoring (Rossano, 2007), advocates that a belief in presence of supernatural agents such as 'God', with their watchful eyes, restrains people from violating norms. The second is supernatural punishment (Johnson and Kruger, 2004), which suggests that a fear of getting punished by supernatural agents deters people from breaking social rules. Both experimental and demographic evidence is available to support these hypotheses (Johnson, 2005; Gervais and Norenzayan, 2012). There is also a possibility that these hypotheses work along with psychological primers such as shame, guilt and empathy to maintain social norms (Johnson and Bering, 2006). Both supernatural

monitoring and punishment might have played a vital role in maintaining sacred sites in India (Gadgil and Vartak, 1974) and are likely to have contributed to fish conservation, as fishes have been connected to supernatural beings (Dandekar, 2011; Katwate et al., 2014), especially associated with temples.

Compliance monitoring and punishment by group members help in maintaining social coherence in humans, however, because these acts are costly for the individuals they are difficult to evolve among egotists (Dahanukar and Watve, 2009; Watve et al., 2011). Supernatural monitoring and punishment therefore might be a cost-free alternative to enhance pro-social behaviour. However, outsourcing punishment to supernatural agents might actually reduce the worldly punishment by the group members (Laurin et al., 2012), and as a result the effect of such punishment will decrease over time. This is mainly because the fear of supernatural punishment is only through belief, and it may or may not be implemented in reality. Current trends in erosion of religious beliefs, and resultant increasing threats to the sacred sites could be partially attributed to this phenomenon. Even though there is increasing religious heterogeneity in India, changing traditions and change in the legal ownership to Forest Departments (FD) (thereby creating a conflict in community and judiciary sanctions) are other possible drivers (Gadgil, 1991; Bhagwat and Rutte, 2006).

Despite the apparent conservation benefits of sacred sites, several ecological and policy oriented concerns remain to be addressed (Dudley et al., 2009). While providing legal status to sacred sites will on one hand help provide additional protection to these fragile areas, the whole concept of

religious values and traditions associated with it will be undermined on the other (Dudley et al., 2009). This is because, legislatively defined conservation sites might in future limit access to local communities, who have until now managed these sites. Additionally, human resource concerns, such as those seen in India, where the FD often cite staff shortage as a reason for poor management and enforcement (Kanagavel et al., 2014), might hinder the effective development and progress of such legal sites.

The most important ecological challenge related to temple fish sanctuaries is the need to manage their upstream reaches, so that stressors originating upstream do not damage ‘sacred sites’ that are often situated downstream. One way to achieve this is through the setting up of ‘safe zones’, where the downstream reaches can benefit due to a spill-over of fish species, and activities such as sustainable and regulated fishery can be promoted which could bring social and economic benefits for local stakeholders (Gupta et al., 2014b). Another emerging question is whether temple sanctuaries serve as ‘arks’ (where fish can mature, reproduce and help repopulate adjoining areas) or ‘cages’ (where fish are able to survive, but unable to reproduce because of unsuitable habitat or other hindrances) (Kumar and Devi, 2013). Whether temple sanctuaries alter the life history traits of fish (for e.g. feeding behaviour, reproduction) therefore need to be understood in greater detail, and is a priority for future research. Unfortunately, religious sites often constrain the ability of researchers to engage in even routine monitoring of fish if it involves capture and handling. Hence, there is a need to explore non-invasive means of stock assessment such as use of hydro acoustics or video cameras.

In spite of various benefits and risks, temple sanctuaries continue to exist in India. However, diminishing dependence on age-old traditional dogmas could mean that religious beliefs and taboos will seldom be prioritised in the future (Bhagwat and Rutte, 2006), and this is especially so in the case of marginalized communities living along river banks for whom fish is a cheap protein source and fisheries a livelihood option. A greater need for understanding both short and long term socio-economic, environmental and conservation impacts of such sacred sites is therefore urgently needed (Berkes, 2004). With the current dearth of conservation options for freshwater biodiversity (Strayer and Dudgeon, 2010), whether sacred sites can be legislatively supported, further developed and utilized as additional safeguarding mechanism can only be ascertained through rigorous scientific studies and involvement of locally relevant stakeholders.

1.2.3 Catch-and-release (C&R) angling as a monitoring tool for freshwater fishes

Catch-and-release (C&R henceforth) angling where local stakeholders cooperate on a common platform has been recommended as a monitoring tool for river ecosystems (Arlinghaus et al., 2002; Arlinghaus, 2006; Granek et al., 2008; Pereira et al., 2008; Cowx et al., 2010; Jena and Gopalakrishnan, 2012; Pinder and Raghavan, 2013). C&R angling has been a popular leisure activity in the Himalayan rivers long before India's independence (Everard and Kataria, 2011). Local fish species such as the golden mahseer (*Tor putitora*) and goonch catfish (*Bagarius bagarius*) have attracted both domestic and international anglers to the region (Pinder and Raghavan, 2013) (see Appendix VI). This activity has provided socio-

economic benefits locally (Everard and Kataria, 2011), and there is an overall positive association among local stakeholders, (i.e. village members, C&R angling associations, C&R anglers and conservationists) towards this activity.

Globally, data from log-books of C&R anglers has assisted with monitoring of fish populations and conservation projects (Marrs et al., 2002; McGarvey et al., 2005; Cooper, 2006; Bishop et al., 2008; Sampson, 2011). The log-book data from C&R anglers visiting the Himalayan Rivers could contribute towards monitoring of fish stocks and provide vital information for scientists. However, carefully designed and environmentally sound guidelines need to be put into place after thorough scientific research and dialogue with local stakeholders, (i.e. village members, C&R angling associations, C&R anglers and conservationists) to address the concerns of C&R angling practices (Granek et al., 2008; Cowx et al., 2010). It will also be valuable to examine the views and opinions of domestic and international C&R anglers visiting the Himalayan Rivers towards protection of their target angling fish species.

1.2.4 Freshwater fish species as a flagship conservation species

The promotion of charismatic species as flagships (Dudgeon, 2000; Walpole and Leader-williams, 2002; Arponen, 2012) can be used to raise awareness and generate funds for conservation initiatives (Johnsingh and Joshua, 1994; Downer, 1996; Bowen-Jones and Entwistle, 2002; Farjon et al., 2004; Clucas et al., 2008). Flagship species have now become an important conservation tool (Caro and O'Doherty, 1999; Barua et al., 2011), and charismatic fish species could contribute towards the protection of river ecosystems. For

example, fish species such as tambaqui (*Colossoma macropomum*) and clown loach (*Botia macracanthus*) have played important flagship roles in the past (Dudgeon, 2000). Therefore, assessing the potential of fish species as flagships could be beneficial for rivers in the Himalayan region. One way to approach this would be by exploring local stakeholders', (i.e. forest managers, C&R anglers and village members) perceptions towards various fish species (Barua et al., 2012).

Currently, there are multiple strategies being applied for the protection and long-term conservation of river ecosystems in India. Unfortunately, these have not obtained their desired results at times, and the growing demand for river resources from an increasing population has played a key role (Sarkar et al., 2013). Despite the multitude of benefits, Indian rivers are facing critical threats (Sarkar et al., 2008), and potential novel conservation approaches need to be investigated to assist with their protection. Such future strategies should have the ability to promote Indian River conservation on a domestic and International stage, provide social (fish as a food source) and economic (job opportunities) benefits to local stakeholders (especially local village communities residing along these rivers); but most importantly, offer protection to rivers and their fish diversity.

1.2 The aim and objectives of the study

The aim of this study was to contribute to the existing knowledge of Himalayan Rivers and their fish species, and suggest novel strategies for their protection and long-term conservation from harmful stressors.

The objectives of this study were to:

1) Study the region's terrestrial protected areas (tPAs) and managed reaches, (i.e. temple pools and C&R angling pools) for potential benefits to Himalayan rivers and their fish species;
2) By combining a review of the literature with informal interactions with stakeholders and an electronic survey targeting recreational fishers in India, describe the history of recreational fisheries development in the country, characterize its current status, and identify issues and opportunities necessary for its sustainable development;
3) Enhance current understanding of the status of recreational angling by assessing the knowledge, attitudes and perceptions of both international and domestic anglers practicing C&R angling in India through the aid of an online survey;
4) Evaluate C&R angling data for mahseer species, and investigate the opinions of stakeholders towards C&R angling and its potential as a management tool;
5) Assess the potential of designating a flagship fish species to promote and assist with the conservation of Himalayan Rivers; and
6) Discuss the idea of setting up of 'freshwater fish safe zones' (FFSZs) to act as a supplementary strategy offering protection to highly

threatened river reaches or fish species requiring urgent legislative intervention.

The achievements of these objectives were attempted through extensive field survey (fish and habitat sampling, semi-structured interviews) in the Indian Himalayan region. The data obtained was analysed using appropriate descriptive and statistical methods.

1.4 The organization of the thesis

The thesis is ordered as follows:

Chapter 2: Study area

Chapter 3: Terrestrial protected areas and managed reaches for threatened freshwater fish conservation

Chapter 4: Status of recreational fisheries in India: development, issues and opportunities

Chapter 5: Assessing recreational fisheries in an emerging economy: knowledge, perceptions and attitudes of catch-and-release anglers in India

Chapter 6: Catch-and-release angling as a management tool for freshwater fish conservation in India

Chapter 7: The 'tiger of Indian rivers': stakeholders' perspectives on the golden mahseer as a flagship fish species

Chapter 8: Conclusion

1.5 The structure and associated limitations of the study

Rigorous field surveys was conducted at all the chosen sampled sites, (i.e. within/outside terrestrial protected areas, temple pools and angling pools) between 2011 and 2013 to obtain significant amount of data for analysis and to draw any conclusions. However, there were various limitations which were encountered during the course of the field surveys. These were as follows:

Chapter 3

The field sites on the sampled rivers, (i.e. Kosi, Ramganga and Khoh) and streams, (i.e. Rajaji Tiger Reserve) were located within tiger reserves, (i.e. Corbett and Rajaji) and elephant corridors, (i.e. Chilikiya-Kota and Malani-Kota) and this often created logistic constraints during field sampling. For example, fish sampling had to be discontinued in the late evenings (after 6 pm) at some sites if wild animals came down to the river/stream for drinking or bathing purposes. These sites would then have to be re-sampled the following day. A couple of field sites could not be sampled for fish species due to the prolonged presence of mugger crocodile (*Crocodylus palustris*) at the location. The weather too played an important role during the sampling period. Apart from the heavy monsoon rains from July onwards; the summer temperatures reached 45°C during the months of April to June, and impacted the health of both the field assistant and myself. All these factors could have affected the sampling, and resulted in less fish species recorded from both unprotected and protected sites. In addition, the fish sampling technique involved the use of cast nets and angling. However, fish catch is highly dependent on the ability of the fisher, (i.e. field assistant and I). This could

have further limited the number of fish species recorded from the sampled sites.

Chapter 4

The recreational angling online survey for the review focused primarily on Indian anglers fishing in Indian rivers. There was an overall support for the survey (200 responses obtained within forty-five days), and was the first online survey of its kind for India. The responses from anglers were grouped under 3 dominant themes, (i.e. criteria (recreational angling activities), associated benefits of recreational angling, and important concerns) during the analysis based on the all the responses obtained (n=200). Although the survey was advertised as widely as possible, one must acknowledge that there could be a possibility that not all respondents were willing to complete the online survey, either due to personal reasons, or inaccessibility to an internet connection. Although the number of responses obtained (n=200) was significant for any analysis to be carried out, a paper-based survey accompanying this online survey could have provided more responses. However, due to financial and time constraints, such an approach was not applied for this research. Any future surveys should combine both a web and paper-based approach, along with interviews with Indian anglers for a broader analysis.

Chapter 5

The global catch-and-release online angling survey too had its limits. 1,339 respondents participated in this six-month long survey however, only 148 respondents (primarily from the UK and India) had actually fished for the

mahseer or other angling fish species in Indian rivers. The Indian respondents in this chapter were different from the respondents from the previous one, (i.e. chapter 4). This was ensured through a rigorous methodological approach, (i.e. a different questionnaire, and allowing only one submission from one IP address), and thorough analysis of individual responses. The responses from all the anglers were grouped under 3 dominant themes, (i.e. activity during catch-and-release angling, benefits to threatened fish species, and reasons) during the analysis based on the all the responses obtained. Although the survey was advertised as widely as possible, a few global angling associations were not at all receptive of this survey and refused to participate in it, often with accompanying verbal abuse. Without the time or financial constraints during this research, paper-based surveys and interviews with international and domestic anglers fishing at the various angling locations in India could have provided more responses for a broader analysis.

Chapter 6

All catch-and-release angling associations located on the Ramganga and Jia Bharali rivers were approached for their logbook data. A majority of the associations willingly provided their logbooks for this particular study. After personally going through their logbooks, it was soon clear that some of the angling associations on the Ramganga and previously on the Kosi River had not maintained a record of their catch data. In addition, one particular angling association situated on the Ramganga River refused to provide the logbook data without any explanation. It was later revealed by other angling associations on the Ramganga River that this particular association had

been under intense scrutiny by the Uttarakhand Forest Department for various reasons. Therefore, the data obtained for this chapter was from two nationally and internationally reputed angling associations on the Ramganga (the Himalayan Outback and the Mahseer Conservancy) and one on the Jia Bharali River (Assam (Bhoralli) Angling and Conservation Association). It would have been interesting to analyse the overall catch data for all the fish species on both these rivers from the angling logbooks of all the angling associations under operation.

The interview respondents (Ramganga River) were chosen based on their approachability, availability and willingness to participate during the numerous field surveys, and subsequently identified under three categories, (i.e. conservationists, people directly associated with angling and village members). They were further defined as 'local stakeholders', (i.e. individual groups aware of or benefitting from the local catch-and-release angling activities). Although both my field assistant and I were fluent in Hindi (the locally spoken language), there was reluctance shown by a few respondents who refused to participate in the interviews. It appeared that our association with the Wildlife Institute of India, Dehradun (although favourable with the forest department) was viewed less positively by these respondents. When further enquired, we were informed that previous responses from some local village members were portrayed in a way (by a different field surveyor) which resulted in misunderstandings between village members and local authorities. Some of the forest managers, (i.e. wardens, rangers and patrol guards) mentioned that, "researchers are keener on publishing papers which

points a direct finger on the forest department, rather than highlighting the plight of forest managers too".

Most of the respondents were also unwilling to speak on record, (i.e. recording device or notes being jotted down) during the interview and preferred that they were listened to and their responses noted down later on. Based on the above responses, semi-structured interview was the preferred technique chosen for this study. The number of interviews conducted daily had to be reduced significantly as a result to allow each individual response to be noted down after the interviews. Although this was successfully achieved, this greatly slowed down the field survey and reduced the approachability of potential respondents. Further, a few of the respondents were more interested in venting out their personal frustration than talk about the topic being discussed. This often slowed down the interviews as each respondent was allowed to express their views and opinions fully irrespective of the outcome, and leading a respondent to an answer was strictly avoided.

All the responses obtained were analysed and grouped under 3 dominant themes, (i.e. conservation benefits, economic incentives and conservation concerns). It was interesting to note that each stakeholder group, (i.e. conservationists, people directly associated with angling, and village members) had their own interest in supporting this activity or speaking against it. Conflict within stakeholder groups was not observed however, conflicting opinions between stakeholder groups were recorded during the analysis. There was a tendency of stakeholder groups of accusing other groups of not doing enough for the betterment of angling target fish species

or conservation of rivers. Although this often gave rise to confrontation among various stakeholder group members if present during the interviews, care was taken to ensure that all groups were allowed to express their views and opinions openly and fully on a common platform.

Chapter 7

The respondents were once again approached depending on their availability during the field surveys, and their willingness to participate in the interview. All the respondents were subsequently identified under three categories, (i.e. forest managers, Indian catch-and-release anglers, and local village members living in close proximity to rivers). All the respondents were questioned regarding five key themes, which were selected through previous pilot surveys in the area, and during interviews conducted with stakeholder groups in chapter 6. These themes were: perceptions of threatened fish of the region, traditional and cultural associations with identified fish, unique features of identified fish, social and economic benefits associated with fish conservation, and suggestion for improved river conservation.

Similar to the previous chapter, (i.e. chapter 6), most of the respondents were unwilling to speak on record, (i.e. recording device or notes being jotted down) during the interview and preferred that they were listened to and their responses noted down later on. The number of interviews conducted daily had to be reduced significantly as a result to allow each individual response to be noted down after the interviews. Semi-structured interview technique was once again the chosen method of interview for this chapter. Although conflict within stakeholder groups was seldom recorded, there was conflict

between stakeholder groups with each blaming the other for not doing enough for river and fish conservation, or for local socio-economic development. This often gave rise to quite heated interviews. Further, there was an overlap of ideas and views during such debates as multiple respondents joined in at times to express their opinion. A rigorous analysis of the responses ensured that all key perceptions, views and opinions of stakeholders were grouped under the five key themes.

Although this research in the Indian Himalayan region had its share of both natural and anthropogenic limitations, significant data was collected for analysis. It should be noted that no survey at this interdisciplinary scale has been previously conducted at the sampled sites. The fish sampling technique could be refined during further field surveys, (e.g. electrofishing for sampling fish populations). Further, structured interviews with key stakeholders would further support the existing and ongoing research activities in the region.

Chapter 2

Study area

The field sites for this research were primarily based in India. The northern Himalayan State of Uttarakhand was chosen as the area of study (Figure 2.1). This selection was based on: (a) the region being encompassed within a biodiversity hotspots of India, (i.e. the Himalayas) with rich endemic floral and faunal species; (b) the presence of terrestrial protected areas (tPAs), (e.g. Corbett and Rajaji Tiger Reserves) with perennial rivers, (e.g. Ramganga, streams) within their boundaries, and managed reaches, (i.e. temple pools and angling pools) situated on the rivers; (c) the availability of local institutional support, (i.e. Wildlife Institute of India, Dehradun) (see Appendix VII); (d) the support of local stakeholders, (i.e. non-governmental organizations (NGOs) such as the Mahseer Conservancy and the Himalayan Outback, village members, conservationists, and C&R angling managements based alongside the rivers) (see Appendix VIII); (e) the presence of active C&R angling for endemic fish species, (i.e. Golden Mahseer (*Tor putitora*)) in the region; (f) the ability to obtain relevant government and departmental permissions, (i.e. Geography Department, King's College London, UK; the Chief Wildlife Warden, Uttarakhand, India; and the Directors and DFOs of Corbett and Rajaji Tiger Reserves, Uttarakhand, India) to sample the Himalayan rivers, (i.e. Kosi (temple pools and angling pools); Ramganga (inside and outside Corbett National Park, temple pools and angling pools); Khoh (temple pools); and streams inside and outside Rajaji National Park) (see Appendix IX); (g) the accessibility of the terrain, and the regular

availability of local and trained field assistants; and (h) the ability to fluently speak, write and understand the local language, Hindi.

2.1 The north-Indian Himalayan state of Uttarakhand

The state of Uttarakhand (formed on the 9th of November, 2000 from the Indian state of Uttar Pradesh) is situated in north India, and has a total geographical area of over 53, 000 km^2 (Sati, 2005). Out of this, ~34, 000 km^2 is covered by forests alone (Directorate of Economics and Statistics, Government of Uttarakhand, 2012-2013). Uttarakhand is enclosed within the Indian Himalayan biogeographic zone – a biodiversity hotspot of India (Sinha et al., 2009), comprises of 13 hilly districts (Sati, 2005), and shares its boundary with China in the north and Nepal in the east (Indian State of Forest Report, 2009). The State has a population of ~8.5 million (Census, 2001), and can be divided into three zones, (i.e. the Himalayas, the Shivaliks and the Terai regions), with temperate to tropical climate (Indian State of Forest Report, 2009). There is a presence of three main seasons here: winter (November to March), summer (March to July) and monsoon (July to November) (Williams et al., 2001). The vegetation of the region can be divided into Trans-Himalayan, sub-alpine, alpine, montane, sub-montane, temperate, sub-tropical, tropical wet evergreen and semi-evergreen (Joshi et al., 2011). The average rainfall recorded in the year 2011 here was ~1, 800 mm. Based on the total reported area (2010-2011), the land use can be divided up into the following classes (all values in hectares): forest area (34, 80,000), cultivable waste land (3, 10,000), fallow (1, 27,000), barren (2, 24,000), non-agricultural uses (2, 17,000), permanent pasture (1, 98,000)

and miscellaneous (3, 85,000) (Directorate of Economics and Statistics, Government of Uttarakhand, 2012-2013).

Uttarakhand is blessed with many perennial and seasonal rivers which provide multitude of benefits not just for the communities living alongside these rivers within the state, but also for millions of people relying on its downstream reaches in neighbouring states, (e.g. Uttar Pradesh and Bihar). The Ganges, the holiest of all Hindu rivers, originates from the Gangotri glacier here, and provides a rich fertile land for people dependent on the vast Indo-Gangetic plain. Some other important rivers include the Yamuna, Bhagirathi, Dhauli Ganga, Kali Ganga, Girthi Ganga, Rishi Ganga, Bal Ganga, Bhilangna, Tons, Alaknanda, Nandakini, Pindar, Kosi and Mandakini (Government of Uttarakhand, 2013; Uttarakhand Tourism Development Board, 2013). These rivers, especially the Ganges, also generate a substantial amount of revenue for the state of Uttarakhand, as they are the pilgrimage centres for millions of Hindu devotees who frequent the state all year around (Sati, 2005).

In order to provide *in situ* protection to its rich biodiversity (Sati, 2005), Uttarakhand has developed a network of 12 terrestrial protected areas (henceforth tPAs), (i.e. 6 national parks and 6 wildlife sanctuaries) (Figure 2.1). In addition, it has 2 terrestrial conservation reserves as well. Together, these cover an area of over 7,000 km^2 (over 14%) of the state's geographical area (Sinha et al., 2009). These tPAs play an important role in protecting the region's endemic floral and faunal species, (i.e. 4,000 plant, 102 mammalian, 623 avian, 124 fish, 69 reptilian and 19 amphibian species) (Government of Uttarakhand 2013; Uttarakhand Tourism Development Board 2013).

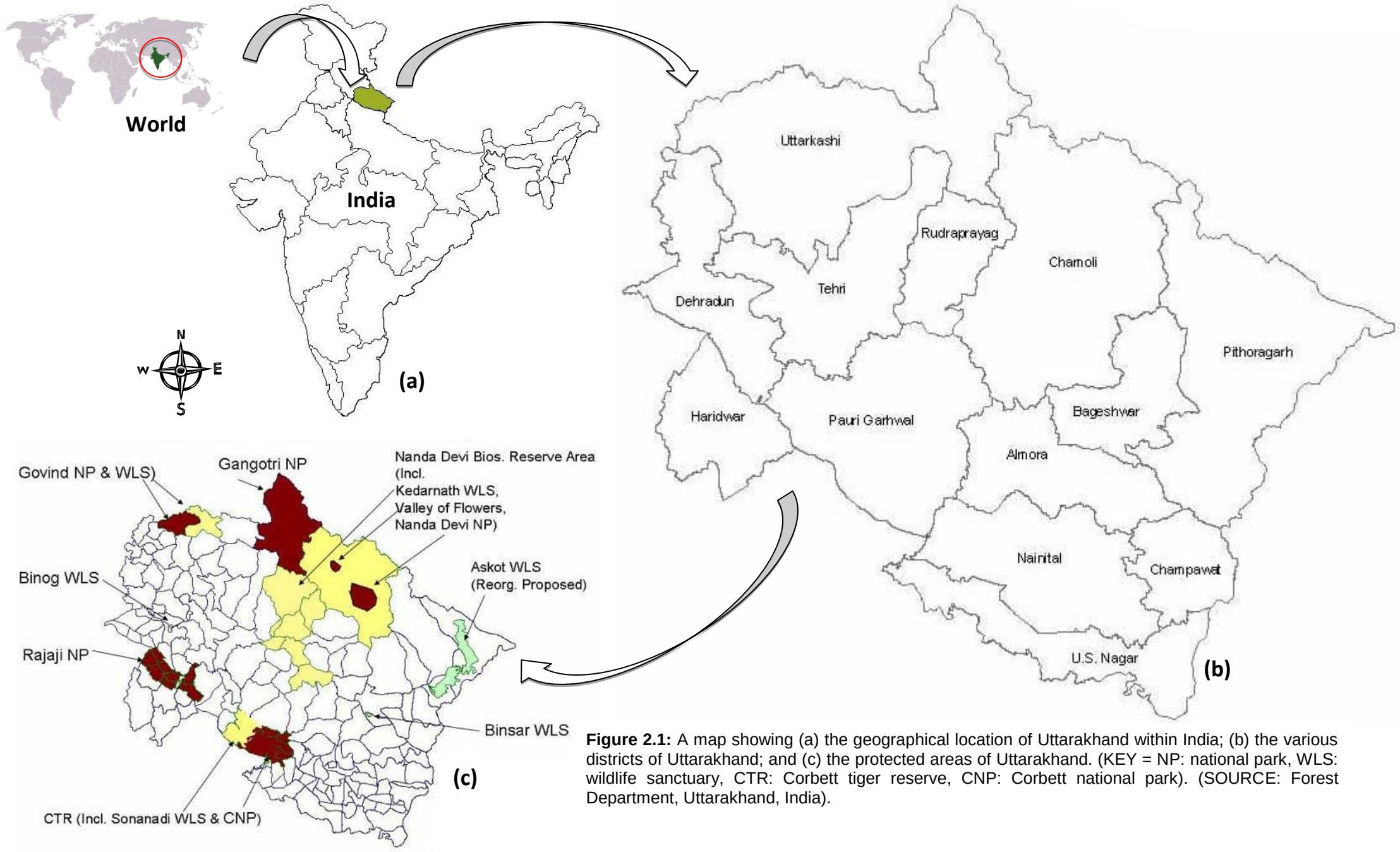

Figure 2.1: A map showing (a) the geographical location of Uttarakhand within India; (b) the various districts of Uttarakhand; and (c) the protected areas of Uttarakhand. (KEY = NP: national park, WLS: wildlife sanctuary, CTR: Corbett tiger reserve, CNP: Corbett national park). (SOURCE: Forest Department, Uttarakhand, India).

2.2 The Corbett National Park

The Corbett National Park (29°25' - 29°39 N, 78°44' - 79°07' E; Figure 2.2.1) is present in the Shivalik mountains, (i.e. the foothills of the Central Himalayas) in the Bhabar-Terai area of Kumaon and Pauri-Garhwal region, and covers an area of 520 km^2 (De and Tiwari, 2008; Badola et al., 2010; Joshi et al., 2011). The Corbett National Park is named after the legendary British hunter and conservationist Edward James "Jim" Corbett (1875-1955), and together with the neighbouring Sonanadi Wildlife Sanctuary and reserve forest areas, forms the Corbett tiger reserve (1, 288 km^2). The altitude of the area varies from 300 - 1,250 m above mean sea level (De and Tiwari, 2008). This park was established on the 8^{th} of August, 1936 making it the first and the oldest national park of India (Joshi et al., 2011). India's tiger (*Panthera tigris*) protection and conservation programme 'Project Tiger' started in Corbett in 1973, and designated this park as the country's first tiger reserve.

The foliage of the area mainly consists of dry and moist deciduous forest, scrub savannah and alluvial grassland (Badola et al., 2010). The vegetation communities are of sal (*Shorea robusta*) dominated forest, sal mixed forest, riverine forest, mixed forest and plantation (Badola et al., 2010; Joshi et al., 2011). The average rainfall recorded here is between 1,400 to 1,800 mm (Joshi et al., 2011). The Ramganga River is the main water source for the park (Figure 2.2.2). This river is joined by smaller tributaries such as Sonanadi, Mandal and Palain Rivers. The Kosi River is situated on its eastern periphery outside the park (Figure 2.2.1), and acts as an additional source of water during the drier summer seasons. Corbett has a rich diversity of faunal species, in particular tigers and Asian elephants (*Elephas*

maximus), along with over 50 mammalian, 600 avian, 33 reptilian, 7 amphibian, 29 fish and 37 dragonflies species (Badola et al., 2010; Joshi et al., 2011). The major threats faced by the park include habitat degradation due to wood and grass cutting, and grazing of cattle by local village communities in the buffer areas (Badola et al., 2010; Joshi et al., 2011).

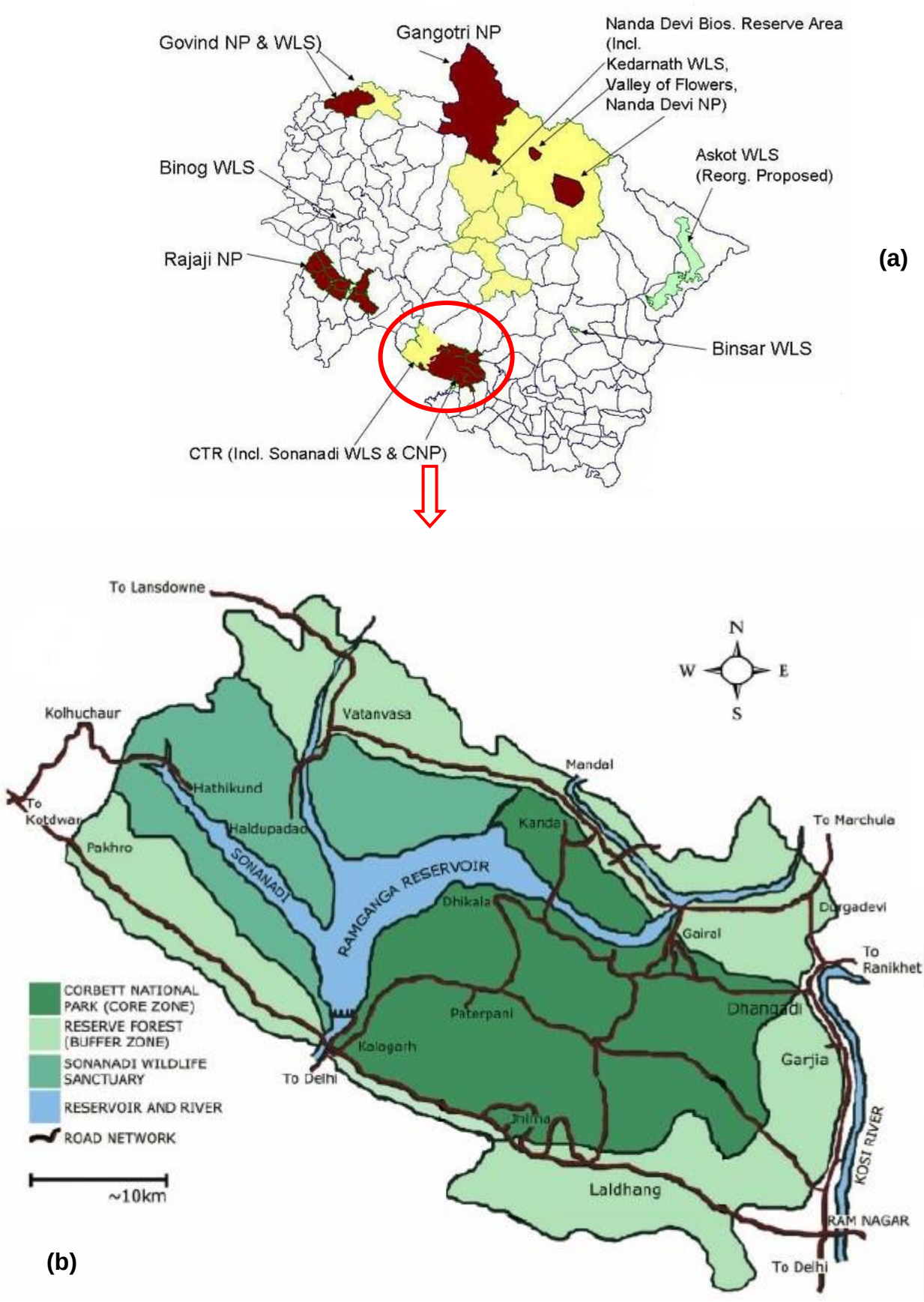

Figure 2.2.1: A map showing (a) the geographical location of Corbett national park within the state of Uttarakhand; and (b) the Corbett national park (KEY = NP: national park, WLS: wildlife sanctuary, CTR: Corbett tiger reserve, CNP: Corbett national park) (SOURCE: Forest Department, Uttarakhand, India; Babu et al., 2009).

Figure 2.2.2: Photographs showing the interior of Corbett national park. The river in the picture is the Ramganga (PHOTO: N. Gupta).

2.3 The Rajaji National Park

The Rajaji National Park (30°00’ N, 30°15’ N; 77°53’ E, 78°07’ E) is situated in the Shivalik ranges of the Indian Himalayas in the districts of Dehradun, Haridwar and Pauri (Laws and Laws, 1984), and is famous for its tiger, elephant and leopard population (Kushwaha et al., 2000; Joshi et al., 2011). Three sanctuaries in Uttarakhand, Rajaji, Motichur and Chilla were merged to form the Rajaji National Park (821 km^2; an elephant reserve) in 1983 (Khanna et al., 2001) (Figure 2.3.1). This park was named after the famous Indian freedom fighter and the first Governor General of independent India C. Rajgopalachari, often known as “Rajaji” (Garhwal Mandal Vikas Nigam, Government of Uttarakhand, 2013; Management Plan of Rajaji National Park 2012-2013 to 2021-2022, Forest Department, Uttarakhand).

The altitude of the area is between 240 to 1,300 m above mean sea level, and it receives an average annual rainfall of 2,300 mm (Kushwaha et al., 2000). The vegetation here comprises of northern tropical moist deciduous forest, divided up into six categories - sal forests, mixed forests, riverside forest, dry deciduous forest, grassland and sub-tropical pine forest (Joshi et al., 2011) (Figure 2.3.2). The Song and Suswa are two perennial rivers which are present on the northern border of the park, and provide a source of water during the drier summer months (Management Plan of Rajaji National Park 2012-2013 to 2021-2022, Forest Department, Uttarakhand). The Ganges River flows through the park and divides it into two parts, in addition to the many streams (*sots*) which remain dry during the summer months, but flood during the monsoon seasons (Williams et al., 2001). The park records show that there are 49 mammalian, 330 avian, 20 reptilian, 12 amphibians, 42 fish

and 60 butterfly species present within its boundaries (Management Plan of Rajaji National Park 2012-2013 to 2021-2022, Forest Department, Uttarakhand).

Due to a rapidly increasing population and urbanisation in its fringes (Ogra, 2009), Rajaji National Park has suffered from various anthropogenic stressors (Joshi et al., 2011), for example, loss of forest corridor along the western boundary of Chilla range (Kushwaha et al., 2000), and conflicts between elephants and the local population (Khanna et al., 2001; Ogra, 2009). The other major problem of this park is the tribal community, *Gujjars*, who stay permanently within its boundaries (Figure 2.3.3a), and rely on the forest and its water sources for their large herds of cattle (Figure 2.3.3b) (Kushwaha et al., 2000; Khanna et al., 2001).

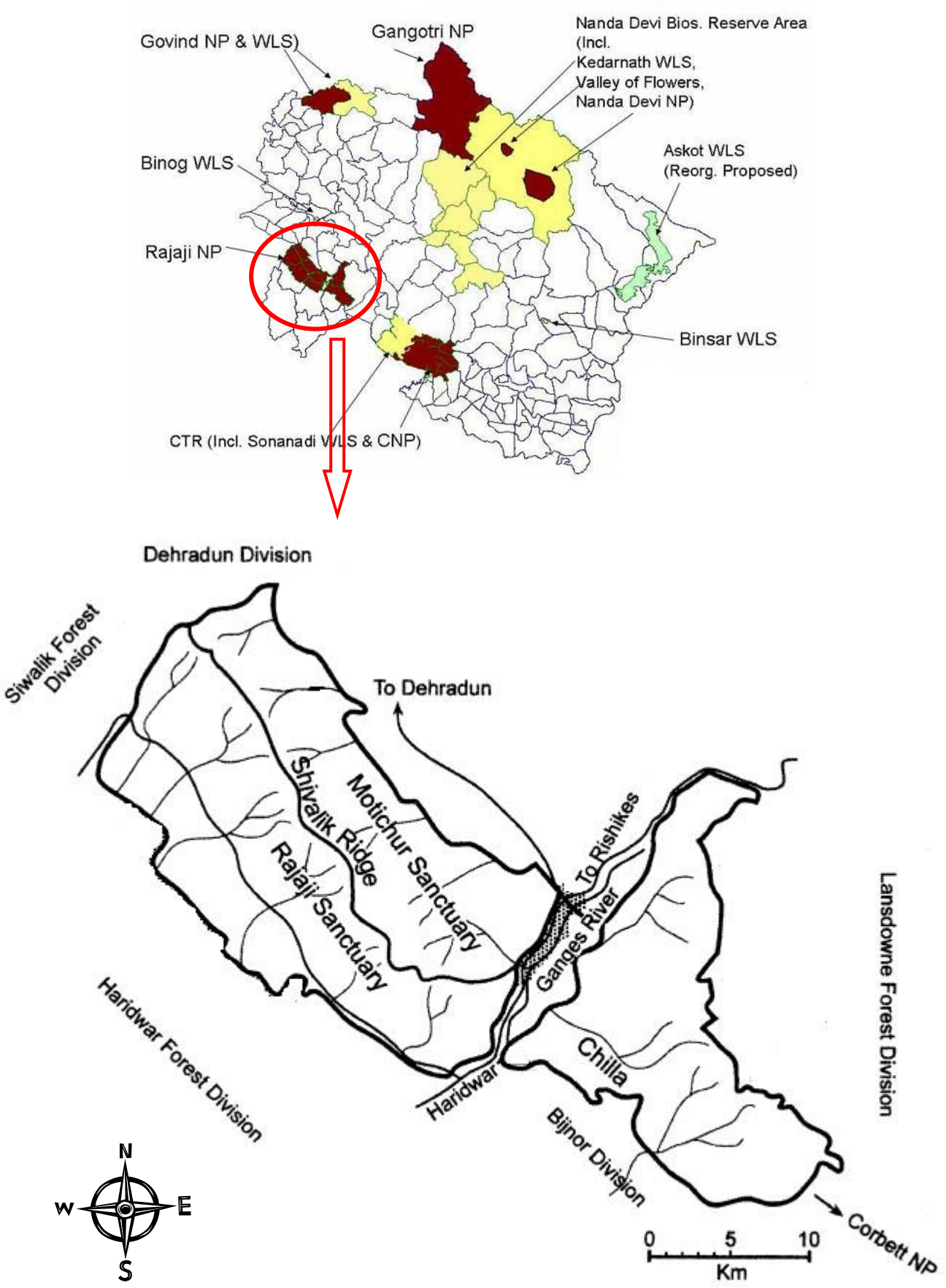

Figure 2.3.1: A map showing (a) the geographical location of Rajaji national park within the state of Uttarakhand; and (b) the Rajaji national park (KEY = NP: national park, WLS: wildlife sanctuary, CTR: Corbett tiger reserve, CNP: Corbett national park) (SOURCE: Forest Department, Uttarakhand, India; Williams et al., 2001).

Figure 2.3.2: Photographs showing the interior of Rajaji national park (PHOTO: N. Gupta).

Figure 2.3.3: Photograph showing (a) a *Gujjar* settlement inside Rajaji national park; and (b) *Gujjar* livestock, (i.e. buffaloes) bathing in an artificial water hole constructed during the peak summer months for park animals (PHOTO: N. Gupta).

2.4 The Kosi river

The Kosi river originates from the Budha Peenath village in the Kausani area of Almora district of Uttarakhand (2,517 m above mean sea level), and has a total length of about 240 km and a catchment area of 3,420 km^2 (Paliwal and Sati, 2009; Kumar and Bahadur, 2013) (Figures 2.4.1 and 2.4.2). The smaller tributaries Saai, Choti Kosi, Sayal, Kushgrah and Ramganga-Gadhera join the Kosi before it meets the Ramganga River downstream near Chamraul in the state of Uttar Pradesh (Sharma, 2007; Kumar and Bahadur, 2013). The major areas enclosed within its basin are Tota-aam and Garjiya in Almora, Ramnagar in Nainital district, Kashipur in Udham Singh Nagar, Dadiyal, Swar, Lalpur and Rampur (Paliwal and Sati, 2009; Kumar and Bahadur, 2013). Despite causing devastating floods during some monsoons, Kosi provides a multitude of benefits for local communities such as water for drinking and washing purposes and industrial use, and various fish species as a local food source (Sharma, 2007). The Kosi is one of the major tributaries of the Ramganga River (Tiwari and Joshi, 2011; Kumar and Bahadur, 2013) and forms the eastern boundary of Corbett National Park (Figure 2.2.1) from Mohan through Dhikuli till Ramnagar (Areendran et al., 2012). Here it provides a source of water for the park animals during the drier summer months (Areendran et al., 2012). Despite also providing a rich agricultural belt, this river continues to face serious anthropogenic stressors (Figures 2.4.3a,b) due to a growing population and a rapid rate of urbanization (Tiwari and Joshi, 2011; Kumar and Bahadur, 2013).

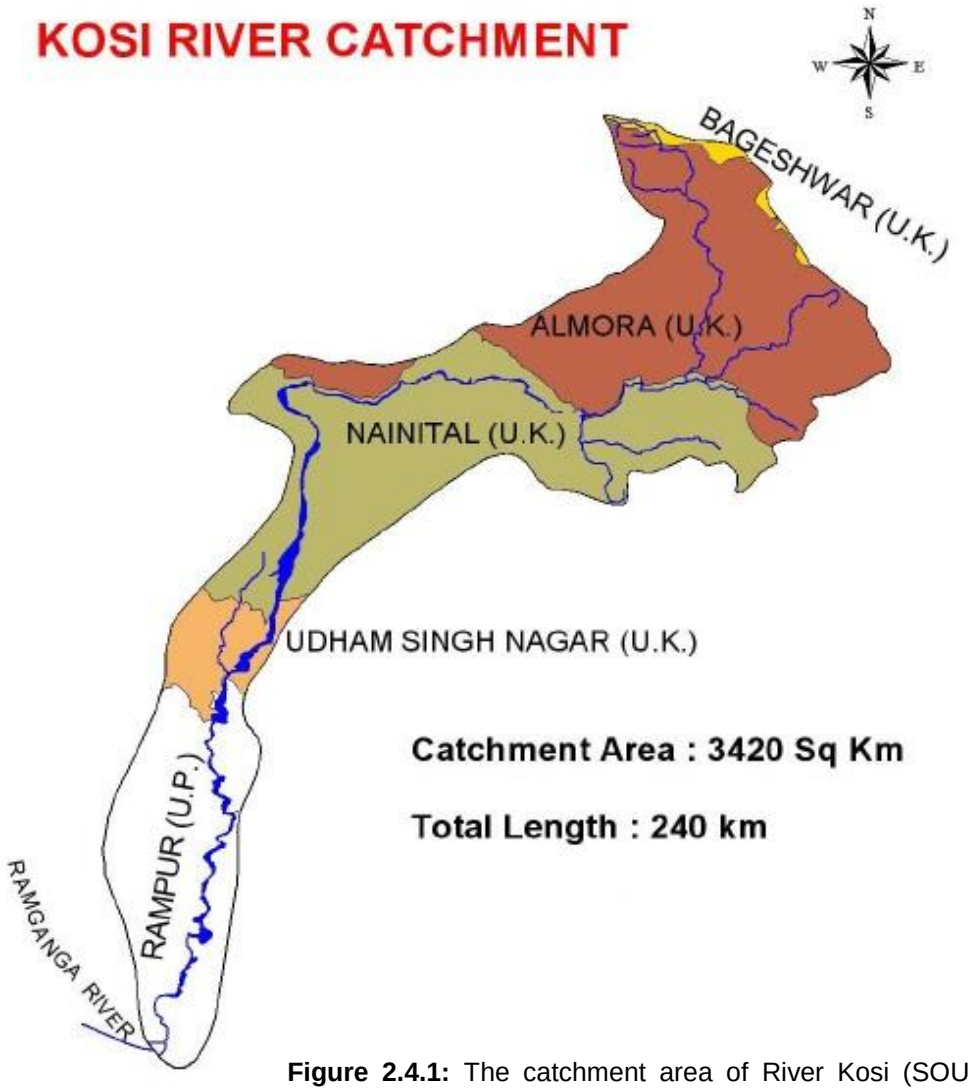

Figure 2.4.1: The catchment area of River Kosi (SOURCE: Sharma, 2007) (KEY = UK: Uttarakhand, UP: Uttar Pradesh).

Figure 2.4.2: Photographs showing the Kosi River (PHOTO: N. Gupta).

Figure 2.4.3: Photographs showing (a) sand mining, and (b) boulder collection, from the Kosi River bed (PHOTO: N. Gupta).

2.5 The Ramganga river

The Ramganga river, a spring fed perennial river (Alam and Pathak, 2010) is an important tributary of the Ganges (Roy and Sinha, 2007), and originates from the Shivalik Himalayas at Dudhatoli in the district of Chamoli in Uttarakhand at an altitude of over 3,000 m above mean sea level (Alam and Pathak, 2010; Srivastava et al., 2011). The river travels through the districts of Chamoli, Nainital and Garhwal (Rao et al., 1991; Alam and Pathak, 2010) for a distance of over 100 km before entering the Corbett national park near Marchula, flows for over 40 km inside the park, and reaches Kalagarh (Tare, 2012) (Figures 2.2.1 and 2.5.1). The major tributaries of the Ramganga are Bino, Gagas, Khatranum Nair, Deotagarh, Badangarh, Mandal, Halgarh and Sonanadi Rivers (Rao et al., 1991). Ramganga is considered the lifeline of Corbett as it is the major water source for the park animals (Figure 2.5.2). The tributaries Palain, Mandal and Sonanadi converge with the Ramganga within the park (Tare, 2012) (Figures 2.2.1 and 2.5.1). From Kalagarh (reservoir constructed here in 1974), Ramganga travels for over 300 km before joining the Ganges near Kannauj in the district of Farrukhabad in Uttar Pradesh (Srivastava et al., 2011), giving it a total length of over 500 km (Tare, 2012) and a catchment area of about 3,10,000 hectares (over 32, 000 km^2) (Rao et al., 1991; Alam and Pathak, 2010). The unprotected reaches of this river (Figure 2.5.3) are currently facing threats such as dumping of domestic sewage, pollution from cremation activities and industrial discharge (Srivastava et al., 2011).

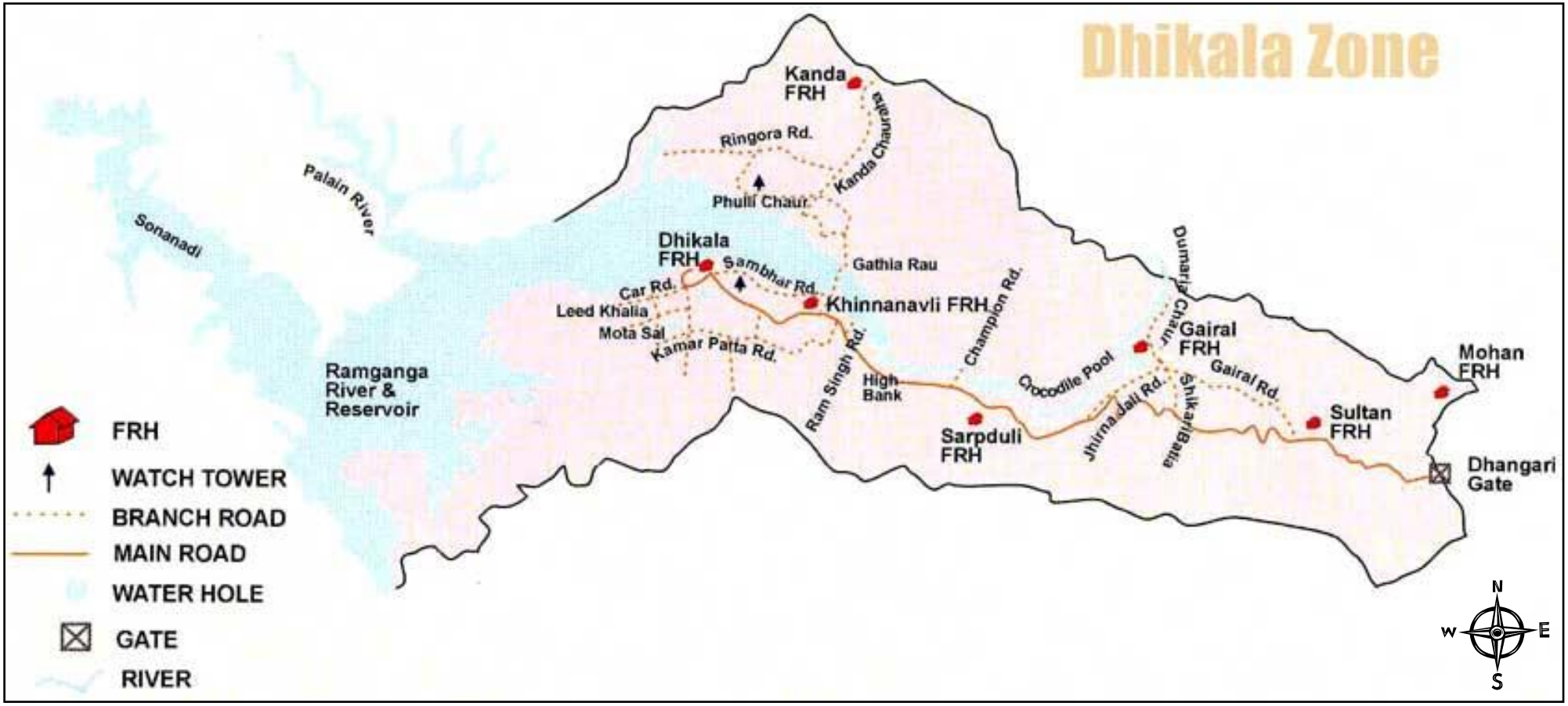

Figure 2.5.1: A map showing the Ramganga River inside Corbett national park (Dhikala zone). Also shown are the Palain and Sonanadi Rivers (SOURCE: Forest Department, Uttarakhand).

Figure 2.5.2: Photographs showing the Ramganga River inside the Corbett national park (PHOTO: N. Gupta).

Figure 2.5.3: Photographs showing the Ramganga River downstream of Corbett national park (PHOTO: N. Gupta).

2.6 The Khoh river

The Khoh, a spring-fed river, is a tributary of the Ramganga, and is situated between N 29°45', E 78°32' and N 29°48', E 78°36' (Atkore, 2005). This river originates at an altitude of 1,951 m above mean sea level from Langur in Dwarikhal (Sharma and Mishra, 2002), drains the Shivalik ranges, and enters the bhabar area to converge with the Ramganga (Atkore, 2005) (Figure 2.6.1). The Khoh is one of the main rivers of the lower Garhwal Himalayas with a catchment basin of over 250 km^2 (Bahuguna, 2013). The main tributaries of Khoh are Gullah Gad, Mahra Gad, Sil Gad, Jawar Gad and Pawai Gad (Bahuguna, 2013).

The town of Kotdwar is located near its banks in southern Pauri-Garhwal district at an altitude of 650 m above mean sea level, and is renowned for religious temples such as Siddhbali and Durgadevi. The reaches of Khoh River which are offered protection, (i.e. through their inclusion within forest divisions, and enforcement of religious sentiments by temples) are in a better ecological state (Figure 2.6.2) compared to the unprotected reaches (Figure 2.6.3). Dumping of domestic and urban waste directly into the river is a key stressor here (Atkore et al., 2011).

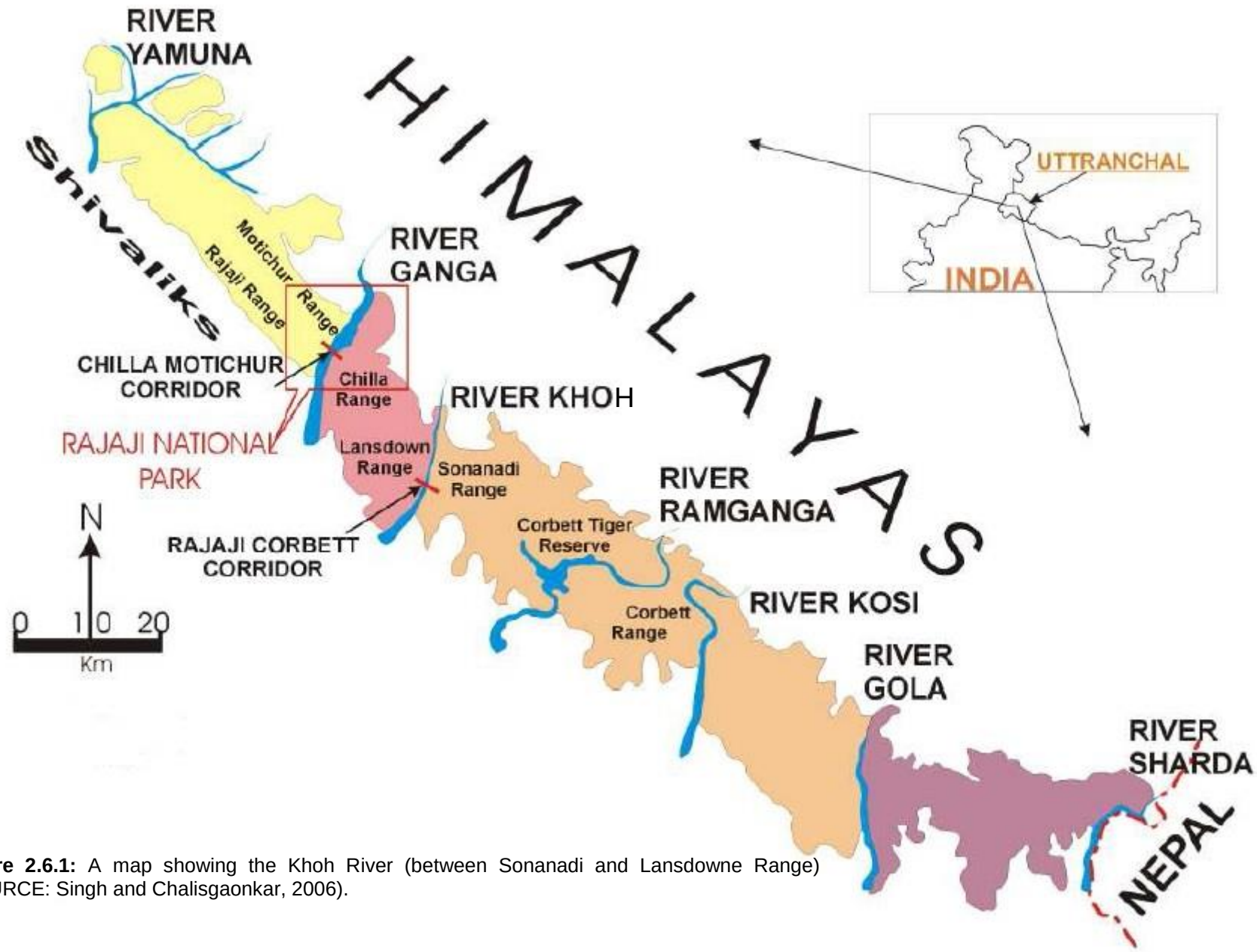

Figure 2.6.1: A map showing the Khoh River (between Sonanadi and Lansdowne Range) (SOURCE: Singh and Chalisgaonkar, 2006).

Figure 2.6.2: Photographs showing the protected reaches of Khoh River (PHOTO: N. Gupta).

Figure 2.6.3: Photographs showing the unprotected reaches of Khoh River (PHOTO: N. Gupta).

2.7 The streams (within and outside Rajaji national park)

There are many streams (*sots*) within Rajaji national park which originate from the southern slopes of the Shivaliks (Tiwari, 1997), such as Soni, Ghasi Ram, Amgadi, Gara, Pipal, Chorpani, Moriya and Mithawali, which usually dry up during the peak summer months. These streams are raging torrents during the monsoon seasons. However, there are a few streams, such as Khairate, Ganesh Gufa, Champa, Agatha, Maluwala, Duberi, Tamakhani, Soni, Lal, Kimka, Falenda and Kali Mitti which provide water for the park animals during the drier periods, and converge with the Ganges River (Figures 2.7.1 and 2.7.2). These streams serve as important breeding and nursery ground for many migrant river fishes.

Water shortage is a key problem facing the park, and this often leads to conflict between the *Gujjar* communities living within the park boundaries and the park animals (Figure 2.7.3a, b). In view of the above, there are many artificial waterholes (Figure 2.7.4a), impoundments (Figures 2.7.4b and 2.7.5a) and weirs (Figure 2.7.5b) which are created by the park management for the animals here (Management Plan of Rajaji National Park 2012-2013 to 2021-2022, Uttarakhand Forest Department).

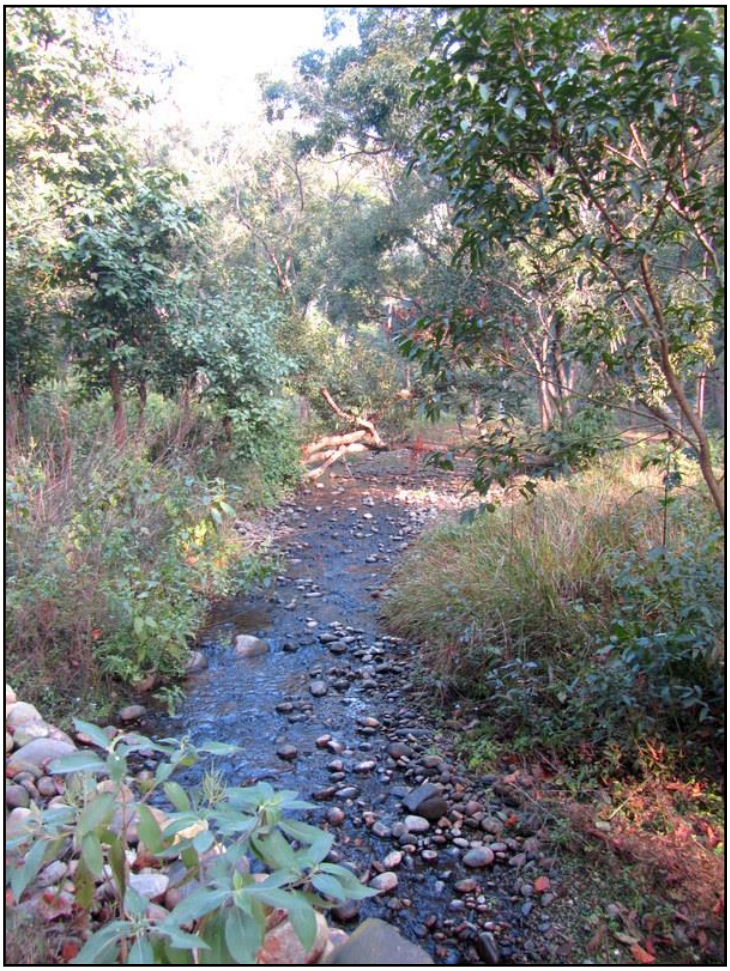

Figure 2.7.1: Photographs showing the streams within Rajaji national park (PHOTO: N. Gupta).

Figure 2.7.2: Photographs showing the streams within Rajaji national park (PHOTO: N. Gupta).

Figure 2.7.3: Photographs showing (a) the *Gujjar* community members in search of water during the peak summer months inside Rajaji national park, and (b) buffaloes from the *Gujjar* community bathing in the water sources of park animals (PHOTO: N. Gupta).

Figure 2.7.4: Photographs showing (a) an artificial waterhole, and (b) an impoundment within Rajaji national park to provide water for park animals (PHOTO: N. Gupta).

Figure 2.7.5: Photographs showing (a) an impoundment, and (b) a weir within Rajaji national park to provide water for park animals (PHOTO: N. Gupta).

Chapter 3

Terrestrial protected areas and managed reaches for threatened freshwater fish conservation

3.1 Abstract

Terrestrial protected areas and river reaches managed by local stakeholders can act as management tools for biodiversity conservation. Further, these areas could have the potential to safeguard fish species found within these water bodies from stressors such as over-fishing, habitat degradation, habitat fragmentation and pollution. In this connection, the study of Corbett and Rajaji tiger reserves, and managed reaches, (i.e. temple pools and recreational angling pools) in conserving threatened freshwater fish species in Uttarakhand, India was carried out from December 2011 – January 2013. Sixty-two sites in major rivers (Kosi, Ramganga, and Khoh) both within protected, (i.e. sites within Corbett and Rajaji, and within managed reaches), and unprotected areas, (i.e. sites outside tiger reserves, and outside managed reaches) were sampled for fish diversity. Lower level of habitat degradation was found inside protected areas. In total, 35 fish species were collected from all sites, including two mahseer (*Tor*) species. Within protected areas, comparatively larger individual fish were found than individuals collected outside of protected areas. Impacts to water quality (mean threat score: 4.3/5.0), illegal fishing (4.3/5.0), diverting water flows

(4.5/5.0), clearing of riparian vegetation (3.8/5.0), and sand and boulder mining (4.0/5.0) were the stressors found outside the sampled protected areas. This study shows the importance of existing terrestrial protected areas and managed sites in Uttarakhand for threatened freshwater fish conservation because such sites have the potential to prevent harmful activities within their defined boundaries through legislative and community-based conservation approaches.

3.2 Introduction

Terrestrial protected areas (henceforth tPAs) are important for biodiversity conservation, genetic resources maintenance and safeguarding ecosystem functions (Keith, 2000; Kingsford and Nevill, 2005; Mancini et al., 2005; Abell et al., 2007; Roux et al., 2008). Adequate representation of aquatic ecosystems within tPAs have been shown to be an effective management strategy for freshwater species conservation (Sarkar et al., 2008; Chessman, 2013). For example, the mean body size of fish species was found to be larger in protected than in unprotected areas of Lake Kariba, Zimbabwe (Sanyanga et al., 1995); in western United States, freshwater preserves have been successfully conserving several fish species (Sarkar et al., 2008); and tPAs have also provided conservation benefits to associated species such as the giant freshwater lobster (*Astacopsis gouldi*) in northern Tasmania (Suski and Cooke, 2007), and freshwater mussels in the Mississippi river basin (Ricciardi et al., 1998). Additionally, recent studies have highlighted the importance of tPAs for freshwater fish species in South Asia (Abraham and Kelkar, 2012; Sarkar et al., 2013). Freshwater reaches managed by local stakeholders, (e.g. community members) has been shown to provide some

benefits to fish species and their associated habitats either through religious beliefs and taboos (Dandekar, 2011), or socio-economic benefits in safeguarding particular fish species (Gupta et al., in press).

A majority of existing tPAs have aquatic bodies as part of their landscape but often view them as associated symbols (Abell et al., 2007; Chessman, 2013). For example, local 'tiger tourist companies' in Uttarakhand speak of the Ramganga River (an important water resource within Corbett Tiger Reserve (henceforth CTR)) as a hotspot for witnessing tigers and Indian elephants (Pers. comm. with tourist companies in Uttarakhand). Further, multiple streams within Rajaji Tiger Reserve (henceforth RTR) are often interlinked through man-made approaches during the peak summer months (April – June) to provide drinking water for park animals (Pers. obs.). Therefore, it is not surprising that present tPAs are only able to offer partial protection (Maitland and Lyle, 1992; Keith, 2000; Knapp and Matthews, 2000) to freshwater aquatic bodies within their landscape; and not fully address concerns such as altered hydrology and at times introductions of non-native species (Saunders et al., 2002; Olarte et al., 2011).

About 5% of India's geographical area is enclosed within PAs (n=691; Pers. comm. with K. Sivakumar). Although debatable, legislatively defined tPAs here do perform protective roles for some floral and faunal species (see Post and Pandav, 2013; Rastogi et al., 2013). Further, aquatic reaches associated with temple pools (see Dandekar, 2011), and reaches managed through local community assistance not only safeguard various threatened freshwater fishes but other semi-aquatic and terrestrial species too (see Gupta, 2013). Additionally, river reaches containing recreational angling

target fish species are protected by various angling organizations in key biodiversity hotspots of India due to associated socio-economic opportunities for local stakeholders (see Pinder and Raghavan, 2013; Gupta et al., in press; Pinder et al., in press).

India is home to major rivers systems (n=7) which contain numerous freshwater fish species (n>900) (Lakra et al., 2010) with high levels of endemism (Pinder and Raghavan, 2013). The fish species here are of importance because they maintain the ecological integrity of freshwater systems (Allen et al., 2010); and also provide a food source for some sections of the society (Gupta et al., in press). However, India's increasing population and subsequent urbanization has put a pressure on its available water resources (Sarkar and Bain, 2007) and fish species (Lakra et al., 2010) through habitat fragmentation, habitat loss, flow alterations, and introduction of non-native species (Everard and Kataria, 2011; Jena and Gopalakrishnan, 2012).

Interestingly, Indian freshwater fishes have not been afforded the support that is directed towards the conservation of mammals, birds and amphibians (Gupta et al., in press). For example, freshwater fish conservation and management policies have suffered from setbacks due to jurisdictional issues and oversights, and implementation of top-down approaches (Raghavan et al., 2011); poor enforcement of existing laws (Raghavan et al., 2013); and community-based conservation initiatives often failing to protect river stretches outside their own jurisdiction (Gupta, 2013). Furthermore, no freshwater fish are afforded mention in the Indian Wildlife (Protection) Act,

1972, the highest legal instrument for wildlife conservation in the country (Dahanukar et al., 2011; Raghavan et al., 2013).

In view of this rising concern for freshwater fish species in India, additional safeguarding options for their protection needs to be investigated to provide vital information and possible assistance to ongoing conservation policies of various government and non-government agencies. Field studies and documented ecological and socio-economic benefits associated with tPAs; temple pools (freshwater reaches safeguarded through religious sentiments and community enforced taboos); and recreational angling pools (prime angling spots on freshwater reaches protected by angling association patrol guards) by the author (see Gupta et al., in press) has been conducted previously. Further examining the freshwater bodies and their fish species within tPAs and managed reaches, (i.e. temple pools and recreational angling pools) in comparison to unprotected reaches, (i.e. sites outside tPAs and outside managed reaches) could offer valuable data for long term scientific research and assist with freshwater fish conservation.

3.3 Methods

The north-Indian State of Uttarakhand was chosen as the sampling location due to the presence of tPAs with perennial freshwater bodies within their boundaries, i.e. Corbett tiger reserve (Ramganga river), and Rajaji tiger reserve (streams) at similar elevation. Also, managed reaches, i.e. temple pools (on Kosi, Ramganga and Khoh rivers) and recreational angling pools

(on Ramganga and Kosi rivers) were present in close proximity to these tPAs (see Figure 3.3.1).

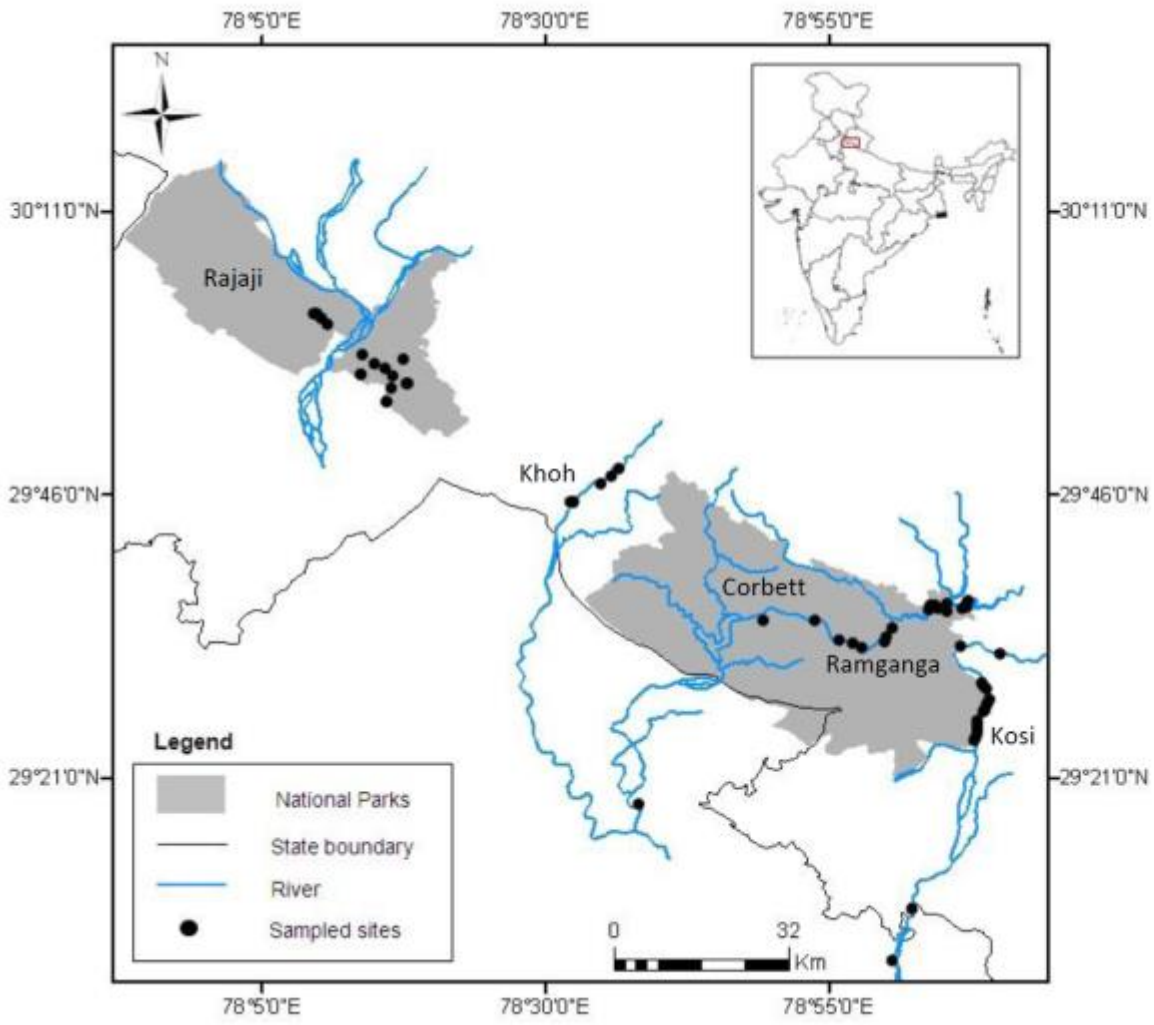

Figure 3.3.1: A map of the study area showing the Corbett and Rajaji Tiger Reserves in the north Indian State of Uttarakhand. Also shown are the Kosi, Ramganga and Khoh rivers. The black dots represent the sampled sites (UNPR and PR).

The freshwater fish species and observed anthropogenic threats were recorded at sixty-two sites during December 2011 – January 2013 under two main categories: Category I: 'unprotected reaches' which consisted of

freshwater reaches outside the tPAs (Corbett and Rajaji) and outside the managed reaches (temple pools and recreational angling pools) (*henceforth UNPR*) (see Figure 3.3.2); and Category II: 'protected reaches' which consisted of freshwater reaches within the tPAs (Corbett and Rajaji) and within the managed reaches (temple pools and recreational angling pools) (*henceforth PR*) (see Figure 3.3.3). Further, data relating to captured fish species and observed anthropogenic stressors were also recorded (at both UNPR and PR reaches) individually for tPAs, temple pools and recreational angling pools to document the protection provided by these separate management approaches (at both UNPR and PR reaches).

Figure 3.3.2: A photo montage of unprotected sites: (a) outside Corbett Tiger Reserve, (b) outside Rajaji Tiger Reserve, (c) outside temple pools, and (d) outside angling pools.

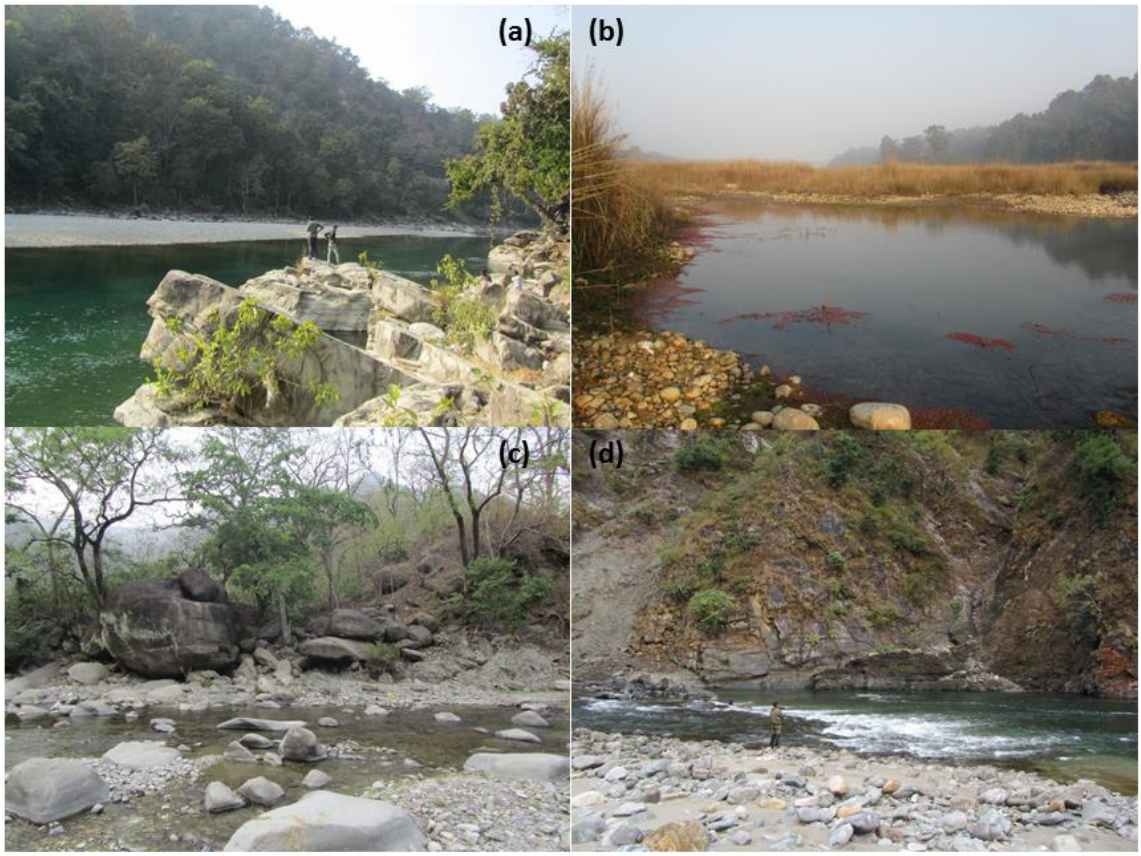

Figure 3.3.3: A photo montage of protected sites: (a) within Corbett Tiger Reserve, (b) within Rajaji Tiger Reserve, (c) within temple pools, and (d) within angling pools.

The study area had potential ecological factors, (e.g. location of tPAs and managed sites, environmental gradient, indicator variables) which could provide bias comparison between protected and unprotected sampled sites (Abraham and Kelkar, 2012). Care was taken to ensure that all treatment groups were similar, i.e. protected and unprotected sites had similar ecological variables in the mid-elevation region hence, sampled for comparison; fish species richness and mean total body length (mm ± SD) was too compared between mid-elevation regions; and the comparison between tPAs + managed sites against non-tPAs + unmanaged sites was based on fish species richness, mean total body length (mm ± SD) of fish

species recorded and observed anthropogenic threats at the sampled sites at mid-elevation region only (Abraham and Kelkar, 2012).

Fish sampling was conducted using cast nets, mosquito net, and catch-and-release (henceforth C&R) angling (Figure 3.3.4). Care was taken to record the nocturnal and crepuscular species. Each site was sampled twice over the entire field survey. After collection, the fishes were kept in water, identified to species level, their numbers counted, measurements such as total body length (mm) recorded using a measuring tape and then the fishes were safely released back into the water. Species richness (S), Shannon-Weiner diversity index (H), index of fish diversity and evenness (E) was calculated for the fish species recorded. Observations regarding the various threats present at each sampling site (UNPR + PR) were recorded through direct observations. The observed threats recorded were grouped into 6 categories (Abraham and Kelkar, 2012). These were sand and boulder mining; dynamite fishing and use of various poisons; overfishing; domestic and urban waste disposal; clearing of riparian vegetation; and water abstraction. Each of these threats were then allocated a score (0 – 5.0; 0 = no impact, 5.0 = most impact).

Figure 3.3.4: Some of the fish sampling methods used on the river reaches: (a) cast net, (b) catch-and-release angling.

3.4 Results

In total, 4,989 individual fish were collected from all the sampled sites (UNPR + PR), comprising of 35 species representing 6 families and 4 orders (Table 3.4.1).

Table 3.4.1: Fish species (n=35) recorded during the study period. Also shown are their IUCN Red List status, population trend and use (SOURCE: IUCN, 2014). Key: * = not evaluated

Order	Family	Species	Status (IUCN Red List)	Population trend	Use and trade
Cypriniformes	Nemacheilidae	*Acanthocobitis botia*	Least Concern	Decreasing	Ornamental
		Schistura beavani	Least Concern	Unknown	Ornamental
		Schistura rupecula	Least Concern	Unknown	Ornamental
		Schistura montana	*	*	*
Perciformes	Channidae	*Channa punctata*	Least Concern	Unknown	Food
Cypriniformes	Cobitidae	*Botia lohachata*	*	*	Ornamental
Cypriniformes	Cyprinidae	*Amblypharyngodon mola*	Least Concern	Stable	Food
		Bangana dero	Least Concern	Unknown	Food, game
		Barilius barila	Least Concern	Unknown	Game, ornamental
		Barilius barna	Least Concern	Stable	Food
		Barilius bendelisis	Least Concern	Stable	Ornamental
		Barilius shacra	Least Concern	Unknown	Ornamental
		Barilius vagra	Least Concern	Unknown	Food
		Cabdio morar	Least Concern	Unknown	Food, ornamental
		Chagunius chagunio	*	*	*
		Crossocheilus latius	Least Concern	Unknown	None recorded
		Garra gotyla	Least Concern	Unknown	Food
		Garra lamta	Least Concern	Unknown	Food
		Gibelion catla	Least Concern	Unknown	Food
		Labeo calbasu	Least Concern	Unknown	Food, game
		Labeo dyocheilus	Least Concern	Unknown	Food
		Labeo pangusia	Near Threatened	Decreasing	Food
		Pethia conchonius	Least Concern	Unknown	Ornamental
		Pethia ticto	Least Concern	Unknown	Ornamental
		Puntius chelynoides	Vulnerable	Decreasing	Food
		Puntius sophore	Least Concern	Unknown	Ornamental
		Raiamas bola	Least Concern	Unknown	Food, game
		Salmostoma acinaces	Least Concern	Unknown	Food
		Schizothorax richardsonii	Vulnerable	Decreasing	Game
		Tor putitora	Endangered	Decreasing	Game, food
		Tor tor	Near Threatened	Decreasing	Food, game
Synbranchiformes	Mastacembelidae	*Mastacembelus armatus*	Least Concern	Unknown	Food
Siluriformes	Sisoridae	*Bagarius bagarius*	Near Threatened	Decreasing	Food, ornamental, game
		Glyptothorax pectinopterus	Least Concern	Unknown	Food
		Glyptothorax telchitta	Least Concern	Unknown	Food, ornamental

The family Cyprinidae was dominant representing 25 species. Cyprinids belonging to the genus *Barilius*, (i.e. *B. barila, B. barna, B. bendelisis, B. schacra* and *B. vagra*) had the highest abundance, (n=2,245). Three Near Threatened, (i.e. *Bagarius bagarius*, *Labeo pangusia*, *Tor tor*); two Vulnerable, (i.e. *Puntius chelynoides*, *Schizothorax richardsonii*) and one Endangered, (i.e. *Tor putitora*) fish species were recorded; all with a decreasing population trend (see Table 3.4.1).

The UNPR on the Kosi (outside temple pools and angling pools) and Khoh (outside temple pools) had almost similar species richness (S) than the PR (within temple pools and angling pools), i.e. Kosi (UNPR, n (number of sampled sites) = 16: S=16; PR, n=5: S=13) and Khoh (UNPR, n=3: S=9, PR, n=3: S=9). However, there was a difference in species richness between UNPR and PR on the Ramganga and streams (Rajaji), i.e. Ramganga: UNPR (outside tPAs, outside temple pools, outside angling pools), n=6: S=12; PR (within tPAs, within temple pools, within angling pools), n=15: S=23; and Rajaji: UNPR (streams outside tPAs), n=4: S=10; PR (streams within tPAs), n=10: S=19.

The following results were obtained for the index of fish diversity (mean ± SD): Kosi (UNPR = 3.80±2.51, PR = 3.33±2.08); Ramganga (UNPR = 8.25±2.63, PR = 9.43±6.29); Khoh (UNPR = 9.00±0.00, PR = 9.00±0.00); and Rajaji (UNPR = 5.00±0.82, PR = 5.40±5.04). The Shannon-Wiener diversity index (H) was calculated for UNPR and PR on all the sampled sites and gave the following results (mean ± SD): Kosi (UNPR = 2.46±0.06, PR = 1.03±0.04); Ramganga (UNPR = 1.41±0.17, PR = 1.56±0.16); Khoh (UNPR

= 1.03±0.02, PR = 1.09±0.01); and Rajaji (UNPR = 1.36±0.03, PR = 1.62±0.12). The evenness (E) values were as follows: Kosi (UNPR = 0.85, PR = 0.53); Ramganga (UNPR = 0.59, PR = 0.47); Khoh (UNPR = 0.58, PR = 0.47); and Rajaji (UNPR = 0.62, PR = 0.53).

Further, to assess the conservation effectiveness of sampled tPAs and managed reaches (temple pools and recreational angling pools) for threatened freshwater fish conservation, the mean total body length (mm ± SD) of threatened fish species (n=6), (i.e. Near Threatened, Vulnerable, and Endangered (IUCN, 2014)) recorded during the sampling was compared between UNPR and PR (Table 3.4.2).

Table 3.4.2: Mean total body length (mm ± SD) of threatened freshwater fish species (n=6) recorded from terrestrial protected areas and managed reaches (unprotected and protected sites). Also shown are the current conservation actions in place for these species. Key: *not recorded; [1,5,6]Near Threatened; [2,3]Vulnerable; [4]Endangered (IUCN, 2014)

Sampled area	Freshwater body	Type of protection	Threatened fish species recorded	Mean total body length (mm±SD)		Conservation action in place within PR
				Unprotected site	Protected site	
Terrestrial protected area (Corbett and Rajaji)	Ramganga (Corbett), streams (Rajaji)	Legislative	*Labeo pangusia*[1]	*	206.50±89.21	None
			Puntius chelynoides[2]	*	250.05±25.12	None
			Schizothorax richardsonii[3]	*	93.00±12.55	None
			Tor putitora[4]	152.26±49.01	296.40±118.84	Habitat conservation
			Tor tor[5]	*	290.00±56.79	None
			Bagarius bagarius[6]	*	657.00±102.20	None
Temple pools	Kosi, Ramganga, Khoh	Religious sentiments and associated taboos	*Schizothorax richardsonii*	*	104.50±21.25	None
			Tor putitora	125.58±25.69	275.31±109.56	Habitat conservation
Recreational angling pools	Kosi, Ramganga	Local stakeholders	*Puntius chelynoides*	*	212.55±35.15	None
			Schizothorax richardsonii	*	125.50±15.57	None
			Tor putitora	145.79±58.52	300.58±99.56	Habitat conservation
			Tor tor	*	292.00±78.99	None
			Bagarius bagarius	*	755.00±105.55	None

Scores (0 = no impact; 5 = most impact) were assigned to the threats (n=6) at all UNPR and PR sites (Table 3.4.3).

Table 3.4.3: Assigned scores (0 = no impact; 5 = most impact) to unprotected (outside tPAs, outside temple pools, outside angling pools) and protected (within tPAs, within temple pools, within angling pools) sites according to the observed threats (n=6)

Threats	**Sand and boulder mining**	**Dynamite fishing and use of various poisons**	**Overfishing**	**Domestic and urban waste**	**Clearing of riparian vegetation**	**Water abstraction**
Type of fishes affected	Substrate dwelling	All	Native and food	All	All	All
Kosi						
Unprotected	5	5	5	4	4	5
Protected	1	1	1	2	3	1
Ramganga						
Unprotected	3	5	5	4	4	4
Protected	0	0	0	1	0	0
Khoh						
Unprotected	4	3	3	5	4	5
Protected	0	1	1	3	1	2
Rajaji						
Unprotected	4	4	4	4	3	4
Protected	0	0	0	1	0	0

At UNPR, water abstraction (mean score; 4.5/5.0); dynamite fishing and use of various poisons (4.3/5.0); overfishing (4.3/5.0); and domestic and urban waste (4.3/5.0) were the main threats recorded. These were closely followed by sand and boulder mining (4.0/5.0) and clearing of riparian vegetation (3.8/5.0). Within PR, domestic and urban waste (1.8/5.0) was the main noted threat (see Table 3.4.3).

3.5 Discussion

Overall, the results show higher species richness and presence of greater number of threatened fish species within tPAs and managed reaches (temple pools and angling pools) (see Table 3.4.2). The index of fish diversity (mean ± SD) was comparatively similar within rivers (UNPR+PR), but dissimilar between rivers. One possible explanation could be due to the presence of specific characteristics of river habitats (Abellan et al., 2007; Sarkar et al., 2013). Similar trends were observed for the Shannon-Weiner diversity index (H) and Evenness (E), and could be due to similar fish diversity, similarity in the relative abundance of fish species, similar geographical distribution, and migratory behaviour of sampled fish species.

Overall, lower threat scores were obtained for sites within tPAs and managed reaches in comparison to unprotected sites (see Table 3.4.3 and Figure 3.5). The lower threat scores in PR highlights the potential conservation benefits of the studied protected sites (tiger reserves, temple pools and angling associations) for fish species from anthropogenic stressors.

Figure 3.5: A photo montage of unprotected sites showing: (a) boulder mining, (b) sand mining, (c) domestic and urban waste, and (d) water abstraction.

When comparing between the three forms of PR, (i.e. tPAs, temple pools and angling pools); tPAs recorded six threatened fish species (IUCN, 2014) in comparison to temple pools (n=2) and angling pools (n=5) (see Table 3.4.2). Interestingly, of the six recorded threatened species (IUCN, 2014), only one (*Tor putitora*) was recorded both from the UNPR and PR sites of tPAs and managed reaches (see Table 3.4.2). This could be attributed to the observed migratory behaviour of this species (Gupta et al., in press). Further, tPAs scored less for observed anthropogenic threats in comparison to managed reaches (see Table 3.4.3). This could be due to the more strictly enforced legislative powers of tPAs (Pers. obs. within CTR and RTR), in comparison to community-driven religious beliefs and associated taboos, or

local stakeholder managed, species-oriented protective patrolling; and could have influenced the number of threatened species recorded from tPAs and managed reaches. The lack of legislative, religious or socio-economic driven protection at UNPR sites could have resulted in increased anthropogenic threats and reduction in fish species richness (see Table 3.4.3).

It is also interesting to note the difference in threat scores between the PR (see Table 3.4.3). PR on the Ramganga (tPAs, temple pools, angling pools) and streams (tPAs) were only subjected to domestic and urban waste (mean score: 1.0/5.0). However, PR on the Kosi (temple pools and angling pools) and Khoh (temple pools) were subjected to a minimum of 5 out of 6 observed threats (see Table 3.4.3). Based on the results obtained, one could argue that a freshwater body's inclusion within temple pools and angling pools alone is less effective in comparison to its inclusion within tPAs. However, despite these observed benefits there are several ecological and policy oriented concerns and challenges associated with tPAs, temple pools and angling pools that need to be addressed (Dudley et al., 2009; Gupta et al., in press) before drawing such comparative conclusions. Further, the studied tPAs were not set up exclusively to protect the region's freshwater fishes unlike the angling pools, and more extensive research is needed before a comparison.

Despite the examined tPAs not encompassing the up- and downstream reaches of the Ramganga (CTR) and the streams (RTR), these tPAs do offer some protection to the studied freshwater bodies and their fish species as uncontrolled human access is completely restricted within these tPAs by

enforcement of various legislative measures. Nonetheless, there are ecological and socio-economic issues associated with tPAs which cannot be overlooked in the long run. For example, various tourist roads, temporary bridges and upcoming lodges on river banks within tPAs contribute to habitat degradation (Gupta et al., in press; see Table 3.4.3). Additionally, semi-structured interviews with local community members living alongside tPAs and forest managers has revealed issues and conflicts regarding rights to forest use (Unpublished data).

There are potential hindrances for the managed reaches too. For example, the diminishing dependence on age-old traditional dogmas could mean that religious beliefs and taboos associated with temple pools here will seldom be prioritised in the future, and this is especially so in the case of communities living along river banks for who fish is a cheap protein source (see Gupta et al., in review). Semi-structured interviews conducted with local priests at the studied temple pools have revealed that illegal fishing practices do occur sporadically at these pools during the night (Unpublished data).

Regardless of the socio-economic benefits of angling pools, recreational angling, in general, has been suggested to negatively affect fish communities, food webs and aquatic ecosystems (see Gupta et al., in press). Further, previous study in the region has highlighted monetary grievances among some local community members, and conservation concerns among scientists and forest managers regarding recreational activity (see Gupta et al., in press). We believe that more field based studies need to be conducted

to better understand the ecological benefits of angling pools for target fish species in the long run.

Nonetheless, it would be unfair to overlook the fact that the studied tPAs and managed reaches were successful in providing some protection to the freshwater bodies and the fish species within their boundaries from anthropogenic stressors. For example, of the 21 recorded food fish species of the region (see Table 3.4.1), 13 were documented only from PR (tPAs and managed sites). These were *A. mola*, *C. morar*, *C. punctata*, *G. lamta*, *G. Catla*, *L. dyocheilus*, *L. pangusia*, *P. chelynoides*, *R. bola*, *T. tor*, *B. bagarius*, *G. pectinopterus* and *G. telchitta*. This could be attributed to overfishing in UNPR which affects food fish species (see Table 3.4.3). The remaining fish species (n=8) were found both within UNPR and PR. Among these eight species, the mean length (mm ± SD) of locally preferred food fish species (Pers. comm. with village members living alongside the sampled rivers; n=5) was significantly higher ($p<0.05$) within PR than UNPR sites. For example, *B. dero* (UNPR: 137.66±32.64, PR: 155.80±20.00; p=0.0028); *B. barna* (UNPR: 56.36±18.48, PR: 63.67±15.56; p=0.0356); *L. calbasu* (UNPR: 142.67±48.79, PR: 185.38±64.81; p=0.0001); *S. acinaces* (UNPR: 56.20±26.68, PR: 73.39±29.03; p=0.0005); and *T. putitora* (UNPR: 152.26±49.02, PR: 296.40±118.84; p=0.0004).

The potential benefits of the studied tPAs and managed sites can be further explained by comparing the mean total body length (mm±SD) of the fish species (n=4) recorded from both UNPR and PR. Although these fish species belong to the Least Concern category (see Table 3.4.1), and are not

very beneficial in assessing the conservation effectiveness of sampled tPAs and managed reaches for freshwater fish conservation, they nonetheless highlight the benefits of PR (tPAs and managed reaches) in the region. These fish species are *B. barna* (UNPR: 56.36±18.48; PR: 63.67±15.56; p=0.0356), *Crossocheilus latius* (UNPR: 46.50±18.78; PR: 65.19±11.72; p=0.0024), *Puntius sophore* (UNPR: 57.44±23.31; PR: 74.41±17.63; p=0.0097), and *Salmostoma acinaces* (UNPR: 56.20±26.68; PR: 73.39±29.03; p=0.0015).

Further, recreational angling, in particular catch-and-release (henceforth C&R) angling is a rapidly emerging leisure activity in the region (Everard and Kataria, 2011). However, since the angling ban within protected areas in 2012 (see Pinder and Raghavan, 2013 for discussion), C&R angling occurs on river reaches outside CTR (Ramganga river) through the issuing of permits by the Uttarakhand Forest Department. The key angling target species are *T. putitora* and *B. bagarius* which attract both domestic and international anglers to the region and bring social and economic benefits to some local communities (Everard and Kataria, 2011). However, *B. bagarius* was only recorded from tPAs (Ramganga River, CTR), a socio-economic concern for the local stakeholders involved in the angling tourism industry here.

Although *T. putitora* was documented from UNPR on the Ramganga river where the present angling pools are located (see Gupta et al., in press); there are several concerns among local stakeholders regarding the anthropogenic threats faced by this species (see Gupta et al., in press).

UNPR on the Ramganga river are subject to rampant dynamite fishing and use of various poisons (mean score: 5.0/5.0) and overfishing (5.0/5.0) (see Table 3.4.3). A decline in this remaining C&R angling target species could influence the viability of the current angling tourism in the region, and negative effect the available socio-economic returns for local stakeholders.

Based on the data obtained during this study, the inclusion of a freshwater body within legislatively defined zones (tPAs), temple pools or angling pools has the potential to offer some protection to the region's freshwater fish species from observed anthropogenic threats. However, the unprotected river reaches outside tPAs; temple pools and angling pools need to be safeguarded from anthropogenic threats to protect locally important food fish species, and angling target species. In view of the observed threats and their intensity of occurrence within unprotected sites, urgent research also needs to be undertaken to ascertain whether the unprotected sites harbour spawning sites or migratory routes of endemic fish species, especially threatened ones for long-term conservation of fish species, and the protection of associated socio-economic benefits.

Chapter 4

Status of recreational fisheries in India: development, issues and opportunities

4.1 Abstract

Recreational fishing is an established activity in developed countries across the world. Apart from providing benefits to regional and national economies, recreational fisheries also generate numerous psycho-social benefits. Many emerging economies and developed countries have well-established recreational fisheries; however in developing countries such as India there has been little discourse on what is needed to support this activity's sustainable development. Here I review the history of recreational fishing and the current status of catch-and-release recreational fisheries in India by combining a literature review with a nation-wide online survey targeting anglers. Analysis revealed various stakeholder-driven recreational fishing associations and outfitters that attract both international and domestic anglers across India, often in biodiversity hotspots. The influx of angling revenue has provided support to local communities, although there are no formal assessments of the true value of such fisheries. With the apparent rising number of domestic anglers in India, there is a demand for new recreational fishing opportunities in both marine and freshwater systems. The lack of scientific knowledge on the basic biology, taxonomy and stress

responses of key sport fish species, targeting of threatened species, and the absence of region- or species-specific angling regulations for recreational fisheries are some of the challenges associated with this sector in India. Moreover, governance structures are still unclear with multiple agencies assuming some responsibility for recreational fishing, but none tasked explicitly with its sustainable development and management. With improved legislative support and a clear policy framework, there is a possibility of developing a responsible and sustainable recreational fisheries industry in India.

4.2 Introduction

Recreational fishing can be defined as fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets (Food and Agriculature Organization [FAO], 2012). Although this activity has a high participation rate in developed countries (average of ~10%) (Arlinghaus and Cooke, 2009; Arlinghaus et al., 2014), the status of recreational fisheries in developing countries are poorly understood (Bower et al., 2014). There are both social and economic benefits associated with recreational angling worldwide (Arlinghaus and Cooke, 2009), and these benefits may be substantial in developing countries (Everard and Kataria, 2011; Pinder and Raghavan, 2013). However, one of the emerging issues for recreational fishing in developing economies is that despite the presence of multiple grass-roots angling organizations and

participants, very little is known regarding the issues and opportunities associated with this activity (Bower et al., 2014). Furthermore, national surveys focusing on recreational anglers as important stakeholder groups are unavailable in most developing countries unlike other jurisdictions like Canada (Brownscombe et al., 2014) and Australia (Henry and Lyle, 2003) where such surveys are common and have been conducted across several decades. In the last few years there has been some interest in implementing such surveys in emerging economies such as Brazil (Freire et al., 2012).

India represents one of the most prominent emerging economies with a population of over 1.2 billion and an annual GDP growth of 5% (2009-2013). India has many large watersheds as well as >7,000 km of coastline. Recreational angling in India dates back to the British Empire when many opportunities were present for anglers worldwide to travel to the rivers here in pursuit of fish species renowned for their fighting skills (Everard and Kataria, 2011). Over the last decade, the recreational angling industry has expanded (as measured by the increasing number of rods per season), and attracted large numbers of international anglers to the region. Yet, most of what is known about recreational fishing in India is anecdotal, and has never been synthesized in a single document.

Globally, recreational fishing has generated substantial income for regional and national economies (Cooke and Cowx, 2004; Cowx et al., 2010; Danylchuk and Cooke, 2011; Everard and Kataria, 2011), but has also been implicated in negative effects on biodiversity and ecosystems (Cooke and

Cowx, 2006; Lewin et al., 2006). Further, while collaboration between recreational fishers and local stakeholders has led to a number of conservation successes, including for initiatives targeting threatened and endangered species (Arlinghaus et al., 2002; Fernandes et al., 2005; Arlinghaus, 2006; Granek et al., 2008; Pereira et al., 2008; Cowx et al., 2010), impacts resulting from recreational fisheries are species-specific and successful outcomes require research and management investments. Unfortunately, a divide between policy makers and anglers in countries such as India has hindered such investments (Pinder and Raghavan, 2013) and underscores the importance of better understanding the sector to inform its responsible development.

By combining a review of the literature with informal interactions with stakeholders and an electronic survey targeting recreational fishers in India, I aim to review the history of recreational fishing and the current status of catch-and-release recreational fisheries in India, and identify issues and opportunities necessary for its sustainable development. I expect the findings from this synthesis to be useful for other emerging economies and developing countries where recreational fisheries development is expected or underway. Although I attempt to provide equal coverage to freshwater and marine fisheries, most recreational fisheries effort in India appears to be focused on inland waters, with accessibility to suitable angling sites being a possible contributing factor.

4.3 Development of recreational fisheries in India

Safeguarding freshwater bodies has been a priority in India since ancient times. During the reign of King Asoka (269 - 232 BC), fishing was prevented during July and November because fish breeding occurred during these months. King Sōmēśvara (1127 AD)'s chapter on angling (Matsyavinōda) in his treatise Mānasōllosā is probably the earliest known writing from India on recreational fisheries (Hora, 1951). The Indian Fisheries Act was enacted in 1897, primarily to regulate destructive fishing methods.

Mahseer (*Tor* spp) were first described in the Ganges in the early 19th century (Hamilton, 1822) and attained popularity as an angling species through the efforts of the Oriental Sporting Magazine (see Nautiyal, 2014). The earliest publications related to angling in British India were written by H.S Thomas and came out in 1873 (Tank Angling in India), and 1897 (The Rod in India). The legendary British hunter and tracker-turned-conservationist Edward James "Jim" Corbett (1875-1955) often spoke of the mahseer in many of his works dealing with tigers and leopards of India. Commercial tackle advertisements from 1897 and 1903 also mentioned mahseer (Figure 4.3). The introduction of brown trout (*Salmo trutta*) in 1860s and rainbow trout (*Oncorhynchus mykiss*) in 1909 by British anglers in streams and rivers of the Himalayas and Western Ghats served to further the popularity of this leisure activity (Sehgal, 1999a,b).

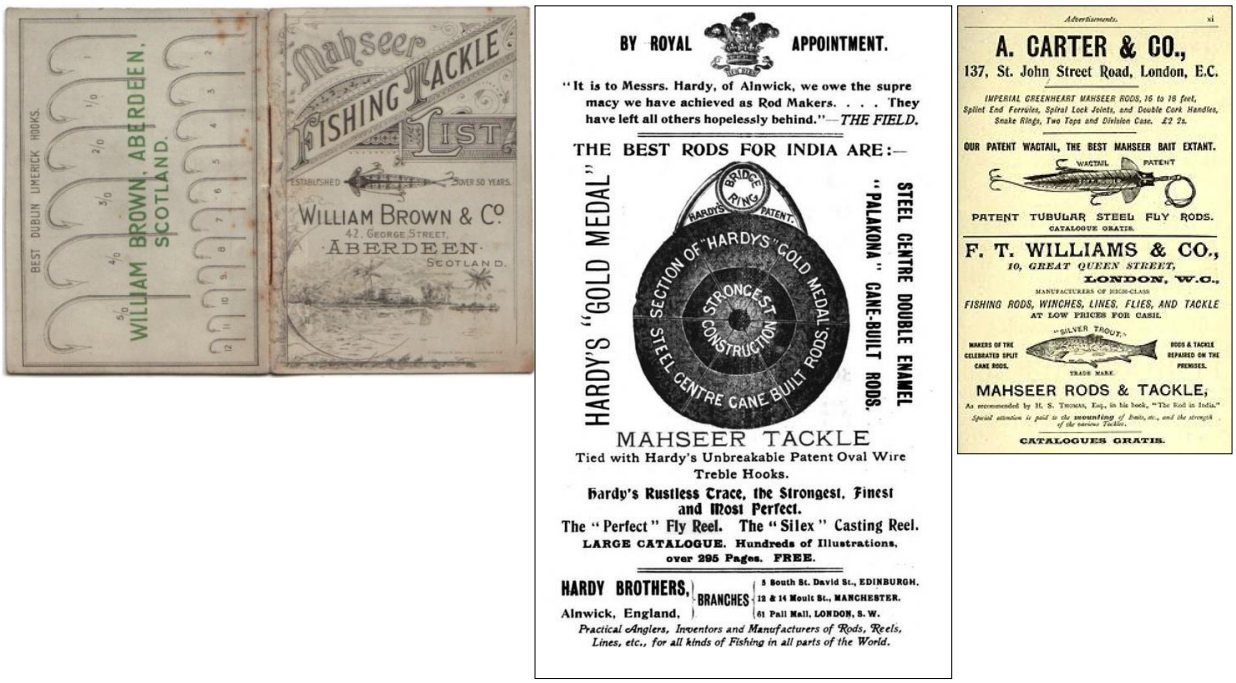

Figure 4.3: Commercial tackle advertisements from 1897 and 1903 mentioning mahseer.

Although recreational angling struggled to maintain its popularity after India's independence, interests of both foreign and Indian anglers began to focus on Indian freshwater systems and its fish species in the 1970s. Established and emerging angling organizations across the country invested both time and money to build on the earlier foundations of sport fishing. In 1976, a 22 km stretch of the Cauvery River in Karnataka was leased by the Wildlife Association of South India (WASI) to protect the Deccan mahseer (*Tor khudree*) from anthropogenic threats. Along with the stocking of mahseer fingerlings, catch-and-release (C&R) angling using rod and line was permitted for both domestic and international anglers. Fishing records were maintained, and management ensured that anglers adhered to local guidelines (Sehgal, 1999b). In 1978, the Indian Tourism Development Corporation (ITDC) in collaboration with Air India and WASI, organized an

event with the Trans World Fishing Expedition (TWFE) and Boote Mission to obtain vital information regarding the mahseer (Sehgal, 1999b). Further, the National Commission on Agriculture recommended a comprehensive survey of mahseers in the Indian water bodies.

Influenced by the successful activities of WASI, the Karnataka state government-owned Jungle Lodges and Resorts (JLR) set up three angling camps in 1980s and 1990s on the Cauvery (at Doddamakali, Galibore and Bheemeshwari), followed by a private fishing camp at Bush-Betta along the same river. Similar to WASI, these efforts ensured both protection for the mahseer species and livelihood benefits for local communities (see Jung, 2012; Pinder and Raghavan, 2013). Further, a UK-based angling organization, Angling Direct Holidays (ADH) collaborated with JLR to bring in clients between January and March each year (Pinder and Raghavan, 2013). In 1993, the Coorg Wildlife Society (CWS) began protecting mahseer on a 28 km stretch of the Cauvery River following the same approach as WASI (Sehgal, 1999b), and increased to 92 km in 2006 (Dinesh et al., 2010) .

In addition to local-scale fisheries management efforts, stocking was also employed as a conservation measure for mahseer. The Tata Electric Companies (TEC) fish seed farm in Lonavala in Maharashtra supplied more than a million mahseer fingerlings to several state fisheries departments and angling associations during the 1980s and 1990s (Ogale, 2002). The Fish Farmers Development Agency (FFDA) in Mysore was involved in releasing some of these fingerlings into the Cauvery (Sehgal, 1999b). In 1987, the

Department of Fisheries, Karnataka set up a mahseer hatchery to produce fingerlings for stocking rivers and reservoirs in the Western Ghats, and a similar hatchery was started by the Karnataka Power Corporation Limited (Sehgal, 1999b).

Fisheries management efforts were not limited to the state of Karnataka or to mahseer. In 2004, a group of local stakeholders from the Mahseer Conservancy secured a lease from the Forest Department for a 24 km stretch of the Ramganga River encompassed within the boundaries of Corbett National Park in the State of Uttarakhand (Mahseer Conservancy, 2014). The objectives of the Conservancy were to promote the conservation of the golden mahseer, *Tor putitora*; attract recreational anglers to the region; utilize the revenue generated from recreational angling to fund conservation projects; and provide social and economic benefits to local communities (Gupta et al., In Press (a)). Further, Jeremy Wade, a world renowned recreational angler helped promote the mahseer and the Goonch catfish (*Bagarius bagarius*) as important angling species through his television series ‘Jungle Hooks India’ and ‘River Monsters’. In northern India, special bylaws of the Indian Fisheries Act permitted the brown and the rainbow trout to be caught in the Himalayan region on rod and line using artificial and live baits, with the fishing season, bag limit and prescribed baits regulated (Sehgal, 1999a).

4.4 Recent developments in Indian recreational fisheries

In April 2009, a legal notice was issued under Section 55 of the Indian Wildlife Protection Act (WPA) to the Karnataka Forest Department questioning the temporary construction of the privately owned Bush Betta fishing camp within the Cauvery Wildlife Sanctuary (see Pinder and Raghavan, 2013). This resulted in the issue of a legal notice to the Central Empowerment Committee (CEC) of the Supreme Court, drawing attention to the potential violation of the WPA by permitting angling within the boundaries of the Cauvery Wildlife Sanctuary. Subsequently, the Union Ministry of Environment and Forest (MoEF) intervened, and angling was banned within the Cauvery Wildlife Sanctuary. In July 2012, recreational angling was halted in all protected areas (PAs) of the country by the direction of the Supreme Court of India (Ajay Dubey vs. National Tiger Conservation Authority (NTCA) (special leave petition no(s).21339/2011)). Today, recreational angling in India is permitted only on river reaches outside PAs, and this is where the majority of foreign and Indian recreational anglers now concentrate their efforts.

Although the number of international anglers visiting the Indian freshwater systems greatly decreased since the angling ban, the number of Indian anglers is reportedly on the rise (N. Gupta per. comm. with angling guides on the Ramganga River) and may be contributing to increases in angling-related expenditures. For example, Indian tackle companies report significant growth

in sales and international companies have shown a keen interest in venturing into the Indian tackle market (N. Gupta, pers. comm. with tackle companies).

In northern India, angling is regulated mainly by the state forest departments who give out rod licenses on a daily basis, while those in the north eastern states are regulated by state fisheries departments (Derek D'Souza, All India Game Fishing Association/AIGFA pers. comm.; also see Everard and Kataria, 2011 for a detailed description). However in the north-eastern states, no regulations are in place including controls on the number of rods. In marine waters, vessels obtain licenses from the respective State Fisheries Department (Derek D'Souza, AIGFA pers. comm.).

Over the past few years, recreational fisheries in marine waters has also emerged as a highly popular leisure activity and many angling associations (see Table 4.4) have helped attract domestic anglers to the Indian ocean and the Bay of Bengal, especially in the seas around the Andaman islands. Approximately 90-120 boats (carrying capacity of 5-6 persons) operate per month in the marine waters during an angling season, which typically extends from October to April depending upon the arrival of monsoon (N. Gupta; S. Panwar pers. comm.).

Table 4.4: Angling based organizations in India

Organization	Approximate membership size	Target fish	Region
All India Game Fishing Association/AIGFA	2200	all	India
Wildlife Association of South India/WASI	350	mahseer	Karnataka
Coorg Wildlife Society/CWS	1000	mahseer	Kodagu, Karnataka
Maharashtra State Angling Association/MSSA	600	carp[a]	Maharashtra
Anglers Association, Futala Lake	5000	carp[a]	Nagpur, Maharashtra
Chennai Anglers Association	1200	marine fish	Tamil Nadu
Cochin Anglers	200	marine fish	Kerala
Jamshedpur Anglers	400	carp[a]	Jharkhand
Kolkata Anglers[b]	8000	carp[a]	West Bengal
Sikkim Anglers Association	500	mahseer, Trout	Sikkim
Naushad Ali Sarovar Samvardhani/NASS	>100	mahseer, Trout	Maharashtra
Anamalai Anglers Association	*	*	Anamalai hills, Tamil Nadu
Assam (Bhoreli) Angling & Conservation Association	>500	mahseer	Assam
Game Fishing India	*	all	Andaman Islands
International Game Fish Association/IGFA	*	all	India
Indian Angler	*	all	India
West Bengal Anglers Association	*	*	West Bengal
Kalimpong Fishing Association	*	*	Kalimpong, West Bengal
Nagaland Anglers Association	*	mahseer, trout	Nagaland
The Himalayan Outback	*	mahseer, trout	Uttarakhand
Tripura Angling Association	*	mahseer, trout	Tripura
Trout Conservation and Angling Association	*	trout	Kullu, Himachal Pradesh
Kemang Angling Association	*	mahseer, trout	Arunachal Pradesh
Pasighat Angling Club	*	mahseer, trout	Arunachal Pradesh
High Range Angling Association	*	trout	Munnar, Kerala

[a]Common Carp and Indian Major Carps (Catla, Rohu and Mrigal)
[b]Comprise of several individual lake-based associations
[*]Not known
Note: The International Game Fish Association has two representatives from India on their International Advisory Committee

4.5 Methodology

4.5.1 India-specific recreational fisheries survey

To characterize the current status of recreational fisheries in India and identify issues and opportunities necessary for its sustainable development, I conducted a survey of Indian anglers who participate in C&R activities. The survey consisted of 23 questions formulated to obtain data pertaining to demographics, fishing locations and target species, angling activity, economics, motivations, and conservation/management perceptions. A web-based survey was deployed over 45 days (from June 2014 to July 2014) to facilitate fast response times and increase participation rates (Oppermann, 1995; Lazar and Preece, 1999; Andrews et al., 2003). An option for additional comments was also provided at the end of the survey (see Appendix X).

The survey was advertised to Indian anglers primarily via conservation/angling websites and forums, and posted on social media (Facebook, Twitter) sites. No changes were made to the survey questions during the course of data collection (Zhang, 2000). Care was taken to allow only one response per individual angler to avoid dual submission (Hasler et al., 2011) by thoroughly analysing each individual responses obtained. Prior to any data collection, a pilot survey was carried out among randomly selected respondents to pinpoint any problems with the completion of the survey (Andrews et al., 2003).

Sampling biases such as non-contact, non-response and refusals are possible due to the methodology employed for this survey, (i.e. an online survey may discourage participation by individuals without easy access to the internet). Care was taken to ensure that the survey was promoted as widely as possible on a variety of online angling sites, forums and groups to attract participation from recreational fishers of all income groups in India. However, it is possible that recreational anglers who practice selective harvest as a means to supplement their diet, (i.e. those whose angling behaviours are more subsistence-based) were less likely to be aware of the survey, as these anglers may be less likely to participate in specialized online forums related to angling. A paper-based approach and structured/semi-structured interviews with Indian recreational fishers could potentially access this broader aspect of the recreational fishing community; an approach that I recommend for further study on this topic. Nonetheless, the responses obtained (n=200), although not necessarily representative of all fishers in Indian recreational fisheries, provides the first overview of Indian recreational fishers and are therefore valuable.

Information was first gathered on preferred fishing locations and target species of interest to anglers. The survey then identified: (a) preferred fishing techniques; (b) factors influencing the angling experience; (c) changes in quality of the angling experience at a particular location; (d) threats to target fish species and fishing locations; (e) awareness of the anglers on the conservation status of target fish species; (f) various conservation strategies which the C&R anglers felt were needed for the protection of target species;

(g) indirect economic expenditures generated by C&R (in Indian Rupees; INR) annually; (h) perception on the value of C&R angling as a conservation strategy; (i) willingness to pay for, and get involved in a conservation initiative in their angling location; and (j) anglers' willingness to contribute time and money for such an initiative. To account for recall and estimation biases, respondent estimates were binned into 10,000 INR categories. Important issues such as security/access/privacy of collected data were taken into consideration.

4.6 Findings

A total of 200 responses were obtained from anglers across India. As respondents chose to answer some, but not all of the questions, the percentages calculated for each question below is based on the complete responses obtained from Indian recreational anglers. The respondents ranged from 14-77 years in age, and resided in 28 states/union territories of India (Table 4.6.1). All respondents were male and most were affiliated with various fishing associations (see Table 4.4). The maximum number of respondents (n=52) belonged to AIGFA, however, 62 anglers were not affiliated with any angling organization. The respondents were asked to record the states/union territories of India that they predominantly fished, of which 27 were highlighted as preferred fishing locations (Table 4.6.1, Figure 4.6).

Table 4.6.1: The Indian States/Union Territories resided, and fished in by the survey respondents (n)

State/Union Territory	Residents (n)	Preferred fishing location (n)	State/Union Territory	Residents (n)	Preferred fishing location (n)
Andaman Islands	2	6	Madhya Pradesh	1	3
Andhra Pradesh	8	8	Maharashtra	45	42
Arunachal Pradesh	2	5	Meghalaya	1	1
Assam	6	8	Mizoram	2	2
Bihar	1	0	Nagaland	2	3
Chandigarh	2	0	Puducherry	1	1
Delhi	17	0	Punjab	2	3
Goa	2	6	Rajasthan	1	2
Gujarat	1	1	Sikkim	3	5
Haryana	3	4	Tamil Nadu	14	17
Himachal Pradesh	6	23	Tripura	1	1
Jammu & Kashmir	2	2	Uttar Pradesh	2	1
Karnataka	46	46	Uttarakhand	4	19
Kerala	5	8	West Bengal	18	18

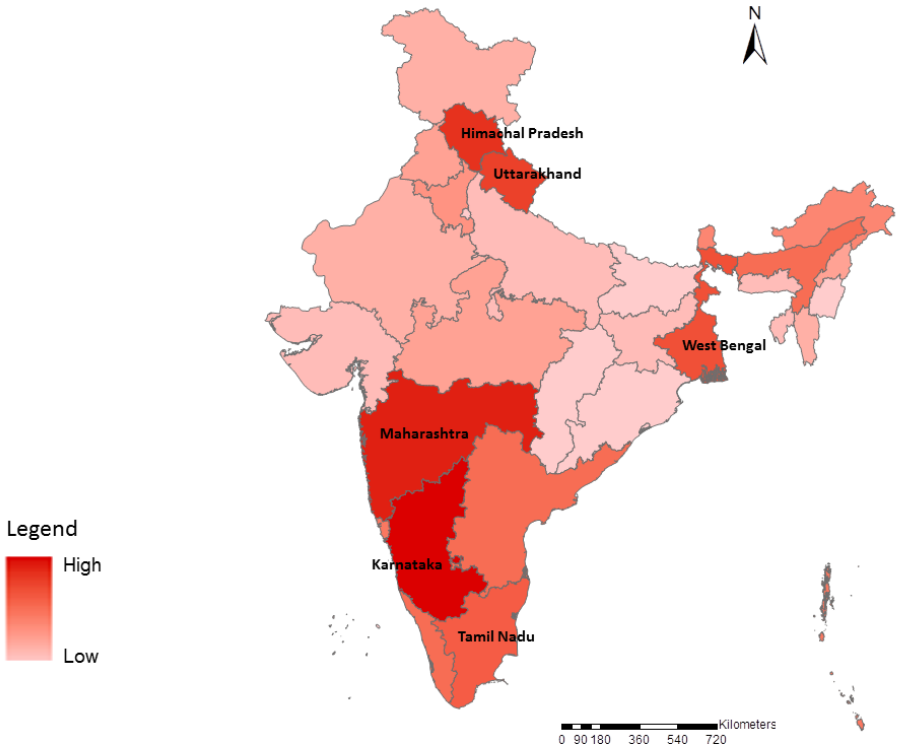

Figure 4.6: A heat map showing the States/Union Territories of India predominantly fished in by the survey respondents (see Table 4.6.1).

The respondents were then asked about their preferred angling method. In order of primary preference, respondents chose bait fishing (51%), 42% spinning rods (42%), and fly fishing (7%). The mean number of days spent angling per year by the respondents was: 0-20 days (28%), 21-40 days (25%), 41-60 days (24%), 61-80 days (7%), 81-100 days (9%), >100 days (7%). The respondents were then asked to identify their main target fish species during recreational angling. A total of 16 freshwater fish species were caught by the respondents (Table 3), among which, 53% of the recreational anglers targeted three mahseer species, *T. putitora* (golden

mahseer), *T. khudree* (Deccan mahseer) and *Neolissochilus hexagonolepis* (copper or chocolate mahseer). In addition, *Gibelion catla* (Indian major carp/catla) was targeted by 13% of anglers (Table 4.6.2). Numerous marine species were also targeted by Indian anglers, including *Caranx ignobilis* (giant trevally; n=11), *Cynoglossus macrostomus* (Tounge sole; n=4), *Gymnosarda unicolor* (dogtooth tuna; n=2), *Lates calcarifer* (Asian sea bass; n=33), *Sphyraena* sp. (barracuda; n=1), and *Thunnus obesus* (big eye tuna; n=1).

Table 4.6.2: Dominant freshwater fish species targeted by the respondents during recreational angling

Fish species	Common name	Conservation Status[a]	Targeted by number of respondents
Anguilla bengalensis	Indian mottled eel	Near Threatened	1
Bagarius bagarius	Goonch	Near Threatened	3
Channa striata	Striped or Cheveron snakehead	Least concern	27
Cirrhinus cirrhosus	Mrigal	Vulnerable	3
Clarias gariepinus	African sharp tooth catfish	Least Concern[b]	12
Gibelion catla	Catla	Least Concern	48
Hypophthalmichthys molitrix	Silver carp	Near Threatened[c]	1
Labeo calbasu	Orangefin labeo	Least Concern	1
Labeo rohita	Rohu	Least Concern	24
Neolissochilus hexagonolepis	Copper/Chocolate mahseer	Near Threatened	66
Oncorhynchus mykiss	Rainbow trout[d]	Not Evaluated	23
Salmo trutta	Brown trout[e]	Least Concern[e]	27
Schizothorax progastus	Dinnawah snow trout	Least Concern	1
Tor khudree	Deccan mahseer	Endangered	59
Tor putitora	Golden mahseer	Endangered	72
Wallago attu	Mully catfish/Freshwater shark	Near Threatened	6

[a]IUCN Red List of Threatened Species™
[b]IUCN assessment based on status in the native range of the species; is an alien invasive species in India
[c]IUCN assessment based on status in the native range of the species; is an exotic species introduced for aquaculture in India
[d]Exotic species introduced into India during the colonial period
[e]IUCN assessment based on status in the native range of the species; is an exotic species introduced into India during the colonial period

Respondents were asked to identify which factors most influenced their angling activities. The responses revealed 8 dominant factors: the season during which angling is conducted (28% of the respondents); the availability of a healthy river with pristine surroundings (14%); the techniques and type of fishing gear used during angling which often determined the fish species hooked (11%); leisure experience, e.g., having a pleasant time with friends (10%); hooking a fish and the size of fish hooked (10%); practising safe catch-and-release angling (10%); the conservation of freshwater ecosystems and fish species (9%); and the availability of fishing locations (8%).

Respondents were also asked to identify the factors that they considered a threat their target species. Seven factors were highlighted by the respondents: overfishing (31% of the respondents); the use of illegal fishing techniques to catch fishes (26%); water pollution, (i.e. domestic and industrial waste being released directly into the freshwater bodies) (18%); the lack of administrative support from authorities, and poor availability of freshwater management strategies (11%); the clearing of riparian habitats to make way for agricultural fields (6%); the upcoming hydro-electric projects which ignore fish passages and the overall impact to the surrounding environment (6%); and the introduction of exotic fish species by individuals and hatcheries to merely increase catch size (2%).

Respondents were then provided with an opportunity to suggest conservation approaches that would benefit and protect their fish species. Here, anglers recommended seven possible management approaches.

These were: strictly practising C&R angling (23% of the respondents); controlling the use of illegal fishing techniques and pollution (18%); spreading mass awareness and educating the local communities living alongside freshwater bodies (18%); providing legislative protection to water bodies (14%); establishing safe zones for fish species to spawn in (13%); involving local communities as stakeholders in conservation policies (8%); and stocking of native fish species (6%).

When asked whether they had witnessed destructive fishing techniques at/near their angling locations, 87% of anglers responded ‘yes’. The respondents were then asked to describe the type of destructive fishing techniques witnessed. Respondents mentioned the use of explosives such as dynamite (36%); the use of illegal fishing nets (32%); the use of poisons (14%); the use of electricity (11%); and 7% mentioned that angling with multiple hooks was causing harm to targeted fish species.

Further, respondents were asked to estimate the amount of money (INR) they put towards recreational angling activities each year. From lowest to highest expenditures, anglers spent: between 0 and 10,000 per year (30%); between 10,001 and 20,000 (13%); between 20,001 and 30,000 (10%); between 30,001 and 40,000 (10%); between 40,001 and 50,000 (7%); between 50,001 and 60,000 (4%); between 90,001 and 100,000 (5%); and over >100,000 (18%). No anglers reported expenditures between 60, 000 and 90, 000 INR.

The average number of fishes caught per year in Indian freshwater systems also varied among anglers. In order from most fish caught to least fish caught, responses ranged from: > 100 fish per year (29%); between 81 and 100 fish per year (13%); between 61 and 80 fish per year (6%); between 41 and 60 fish per year (11%); between 21 and 40 fish per year (20%); and, between 0 and 20 fish per year (21%). Further, 51% of the recreational anglers mentioned that on average they returned 91-100% of the fish caught back into the river. When asked about their awareness of the conservation status, (i.e. endangered/vulnerable/near threatened) of the fish species they primarily targeted, 40% of the respondents were strongly aware of the conservation status, 31% were aware, 22% were somewhat aware, and 7% were not at all aware of the fish's conservation status.

Finally, respondents were asked whether they thought recreational angling could benefit the conservation of freshwater fish species in India. The majority of respondents replied by saying yes (93%); 3% of respondents were doubtful; and 4% of respondents felt that C&R would not benefit their target species in any way. Various explanations were provided by the recreational anglers in support of their choice (Table 4.6.3). The respondents were further questioned about their willingness to get involved in a conservation initiative in their angling region, if provided with an opportunity to do so. Most anglers were willing to get involved (90%); while 8% were unsure; and 2% were unwilling to get involved in any conservation project. When asked if they would also be willing to contribute financially to conservation projects, 76% of the respondents were willing to contribute both

their time and money for such conservation initiatives; 12% were only willing to contribute their time; 3% only their money; and 9% neither their time nor money.

Table 4.6.3: Dominant responses from Indian recreational anglers regarding the benefits of angling for freshwater fishes, and their associated concerns

Criteria (recreational angling activities)	Associated benefits of recreational angling	Important concerns
a) Provides social and economic opportunities b) Generates funds locally	a) Create jobs for local stakeholders, and possibly poachers b) Funds can support targeted conservation projects c) Economic betterment of local communities	a) Lack of government support b) Urgent need to set up recreational angling conservation units within village communities
a) Patrolling by anglers during angling activities; large freshwater reaches covered in search of target fish species b) Presence of anglers along river banks during angling	a) Presence of anglers often keeps poachers away b) Prevents use of illegal fishing techniques at river reaches where anglers are camped c) Prevents boulder and sand mining at times d) Anglers have reported potential stressors to local authorities in the past	a) Poachers are seldom dealt with by concerned authorities b) No formal protection of critical fish habitats from anthropogenic threats
a) Recreational angling has the potential to be practised as per environmental guidelines: (i) Appropriate handing, air exposure and release of fish (ii) Type of hook used checked (iii) Maintaining anglers' logbook	a) Reduce damage to targeted fish species b) Provide fish date to scientists	a) More scientific studies are needed regarding recreational angling within Indian freshwater bodies
a) Education and awareness through recreational angling: (i) Organizing angling camps, competitions and prizes (ii) Involving mass media during such activities	a) Highlight the importance of freshwater ecosystem, and generate interest on regional and national level b) Anglers as an important local stakeholder group can influence policies in the long run	a) Public awareness regarding freshwater bodies and fishes is lacking greatly

4.7 Issues facing the present recreational angling sector in India

Despite the potential benefits that can be harnessed from recreational fisheries in India, there are various issues that need urgent attention, as they could be constraining the sustainable development of this sector here. I present a list of the key issues identified from informal interactions with fisheries managers and anglers is India and our broader understanding of issues that have been experienced in other jurisdictions.

4.7.1 Lack of information on basic biology and taxonomy of game fish

In India, freshwater fish are poorly studied, with little or no information available on the biology, ecology and population status of the vast majority of species (Dahanukar et al., 2011), including those targeted in recreational fisheries. There are significant knowledge gaps in the understanding of taxonomy and natural history for even charismatic and popular species, such as the mahseer which have been documented since the 12th century. Uncertainties also exist surrounding the actual number of mahseer species found in India and their exact distribution (Pinder and Raghavan, 2013). The most popular mahseer species targeted by anglers in India, the 'Cauvery humpbacked mahseer' awaits the recognition of a scientific name, and other species such as *T. putitora*, *T. tor* and *T. khudree*, currently known to have a wide range of distribution, could in fact be 'species complexes' comprised of several range-restricted species, many of which would need formal taxonomic recognition.

Although numerous studies are available on the natural history of some mahseers (for a review see Nautiyal, 2014), the ambiguities surrounding species taxonomy and distribution makes these of little value for practical conservation planning and action. But for others (e.g., chocolate mahseer, *N. hexagonolepis*) (see Table 4.6.2), there have been very few biological studies conducted. The situation is similar for the Goonch, *Bagarius bagarius*, one of the largest freshwater catfish occurring in the Indian subcontinent, which has very complex taxonomy and genuine knowledge of distribution is therefore limited (see Ng, 2010).

Undertaking scientific research for many of the species discussed above is a challenge given that habitats are often located in remote areas which are not easily accessible, not accessible year-round (Pinder et al., In Press), and/or are located inside protected areas where research permits are difficult to obtain (Madhusudan et al., 2006).

Recreational fisheries, therefore, could play an important role in supporting research on many such freshwater species that are otherwise difficult to sample, as demonstrated through a recent study using angler catch data to generate biological information for conservation and management of mahseers in the Cauvery (Pinder et al., In Press).

4.7.2 Lack of understanding of biotic responses to capture and release

There are no studies to date that have examined post-capture mortalities in mahseer or other species targeted by anglers in India, but studies have assumed (with no scientific backing) that many of them may die owing to the exhaustion, injuries and associated infections (see Dinesh et al., 2010). The type of fishing gear used can have an effect on the mortality rate of fish caught by C&R angling (Cooke and Schramm, 2007; Danylchuk et al., 2014; Rocklin et al., 2014). In comparison to artificial lures and flies,; natural, worm-baited and live baits have been shown to increase the mortality rates among fish species due to deeper hooking (Clapp, 1989; Payer, 1989; Siewert, 1990; Wilde et al., 2000). Also, circle hooks have been found to decrease angling mortality in C&R among fish species in that they promote shallow hooking (Cooke and Suski, 2004). Barbless hooks tend to reduce the handling time required to remove the hook (Cooke et al., 2001; Schaeffer, 2002) and lessen the tissue damage to fish species (Casselman, 2005).

The lack of information on the effects of C&R practices on common sports fish of India makes it difficult to determine the extent to which the activity is sustainable. Moreover, given that many recreational fisheries management strategies (e.g., minimum size limits, closed seasons for some species) require release of some fish, it is difficult for fisheries managers to know which regulator approaches may be appropriate. There is a clear need for research on the post-release mortality rates of key recreationally-targeted species (especially those that are imperilled) in India. Additional studies

focused on understanding the factors that mediate mortality or sub-lethal (physiological, behavioural) impacts will be useful in the development of best practices that can be shared with the angling community to ensure that C&R practices are responsible and sustainable (Cooke and Suski, 2005; see below).

4.7.3 Need for development and dissemination of best practices for sustainable angling promotion

Presently, there are no official guidelines relevant to recreational fisheries that exist in India, and there is no monitoring of these fisheries. The onus therefore is solely on the angling associations, and many of them advocate best management practices. For example, in June 2014 an 'All India Fresh Water Angling Competition' organised by AIGFA in partnership with Maharashtra State Angling Association and WASI in River Cauvery was attended by over 30 recreational anglers (Derek D'Souza, AIGFA pers. comm.). A set of nine recreational angling guidelines were provided to each participant (including mandatory catch-and-release), and anglers had to abide by these rules to stay in the competition.

However, such practices are not advocated or used by many angling associations. For example, a quick survey of the photographs on closed group pages of angling associations in India revealed that wall nails were being used as fish hooks by some members; the air exposure to fish was often unacceptable, (e.g., fish photographed >20 m away from the water

body); and visible wounds were present on captured fishes which were going to be released back into the water. Reducing the prevalence of such practices will require increasing awareness through angler education and encouraging compliance through enforcement by a statutory recreational angling body (see Figure 4.7.3).

Figure 4.7.3: Current recreational angling practices in India, as depicted by photographs on angling association websites.

4.7.4 Unregulated stocking and introductions

To some extent, the development of recreational fisheries in India has been aided by stocking and introduction of both exotic species and captive bred populations of native species. During the British Raj, many upland lakes and upper reaches of rivers were regularly stocked with exotic salmonids to develop recreational fishing opportunities. It has been documented that five species of salmonids: brown trout (*S. trutta*), rainbow trout (*O. mykiss*), eastern brook trout (*Salvelinus fontinalis*), splake (brook trout X lake trout; *Salvelinus namaycush X S. fontinalis*) and a land-locked variety of Atlantic salmon (*Salmo salar*) were introduced in the Himalayan waters between 1905 and 1969, of which only the brown trout established self-sustaining populations, subsequently impacting endemic snow trout (Sehgal, 1999a).

Similar stocking programs have been carried out in the Nilgiri, Anamalai and Cardamom hills of the Western Ghats (Sehgal, 1999b) with trout hatcheries set up in Avalanche (Nilgiris) and Eravikulam-Rajamalai (Munnar, Kerala). That recreational fishing for trout continues to take place in these regions to this day, actively encouraged by the local angling associations (see Table 4.4), is indicative of the presence of either self-sustaining populations of these exotic species, or continuous stocking from the local hatcheries.

The biological and socio-economic impacts of the angling for exotic fish species (*S. trutta* and *O. mykiss* in the Himalayas; *Cyprinus carpio*, and *O. mykiss* in the Western Ghats) is poorly understood, especially with regard to

large-scale stocking of such species in areas of high biodiversity and endemism. In this context, there is also a specific need to assess in detail the preferences and awareness among C&R anglers regarding the targeting of native and non-native fishes, to understand the extent to which anglers target non-native fish species (see Hickley and Chare, 2004; Nguyen et al., 2013) and to gauge support for stocking to enhance recreational fishing experience (see Granek et al., 2008). Given the relationship between stakeholder support and the success of management and conservation initiatives (for e.g., see (Jensen et al., 2009; Jentoft et al., 2012; Song and Chuenpagdee, 2014), evaluating the attitudes of anglers and other stakeholders on issues related to stocking would help to inform management decisions.

Large scale stock replenishment of various 'species' of mahseer has been carried out in the Western Ghats region, particularly in the Cauvery River (see Ogale, 2002), which has resulted in the reported proliferation of hybrids and the suspected decline of native lineages (Dinesh et al., 2010; Pinder and Raghavan, 2013). It is known that the Tata Electric Company in Lonavala, the source of most stocked fingerlings in the Cauvery, experimentally hybridized mahseer species (Ogale and Kulkarni, 1987) and have provided fingerlings of various mahseer species including '*Tor mussullah*' (now understood to represent a distinct genus; see Knight et al., 2014) to different angling associations in India (Ogale, 2002). In the case of the Cauvery, no historical information is available to describe the original mahseer community prior to this stocking program, and its implications for the genetic integrity of populations are unknown (Pinder and Raghavan, 2013). The current diversity

of mahseer in the Cauvery is a ‘taxonomist’s nightmare’ with several phenotypes being recorded, and none of them matching historic species descriptions.

4.7.5 Fisheries focused on biodiversity hotspots

The survey reveals that the most popular fishing locations were in the Himalayas and Western Ghats, two of the important biodiversity hotspots known for their exceptional freshwater fish diversity and endemism, which are also currently threatened by numerous anthropogenic pressures (Vishwanath et al., 2010; Dahanukar et al., 2011). Although some species targeted by anglers in India have shown a declining population trend and are listed as threatened in the IUCN Red List, (e.g., *T*. *khudree* and *T*. *putitora*, assessed as ‘Endangered’; the goonch catfish, *B. bagarius* assessed as ‘Near Threatened’; and *Cirrhinus cirrhosus* assessed as ‘Vulnerable’), none of these assessments list recreational angling as a threat to the species (see species specific accounts in the IUCN Red List of Threatened Species), possibly because no studies have been carried out to assess the impacts of recreational fisheries (Cooke et al., In Press).

4.7.6 Poorly defined governance structures

Both within, and among the Indian states and union territories, the multijurisdictional nature of fisheries governance (see Raghavan et al., 2012) has played a substantial role in slowing the development of recreational

fisheries sector. For example, absence of a centralised governing body has constrained decision-making capabilities at both the national and state level. A centralised governing body with legislative support and funding will be crucial to oversight, management, and regulation of sustainable recreational fisheries in India. Although a large majority of angling associations in India are registered and catalogue the practice of recreational angling through paid permits, a number of unlicensed angling associations continue to operate in major angling locations of India as 62 of the 200 respondents in this study were not affiliated with any angling organization.

The ever-dynamic disconnect between recreational fisheries management associations and government agencies, (e.g., forest and fisheries departments) are an additional obstacle to the sustainable development of recreational fisheries sector in India. In the Himalayan region for example, the Forest Department is currently responsible for issuing recreational fishing permits (at a set price) to anglers fishing in the Ramganga River, but there is limited capacity within the department for patrolling freshwater reaches including angling spots (Gupta et al., In Press (b)). In addition, an ongoing concern regarding the distribution of revenue generated through the fishing permits between the Forest Department, angling associations and village communities has led to the suggestion that the Uttarakhand Fisheries Department should manage recreational angling in the region (Gupta et al., In Press(b)).

Although recreational angling tourism in India provides social and economic benefits to some local communities (Everard and Kataria, 2011; Pinder and Raghavan, 2013), concerns have been raised by local stakeholders regarding transparency during profit sharing stages (Gupta et al., In Press (b)). A recent suggestion by an angling association operating on the Ramganga River in Uttarakhand to introduce a conservation tax (US$ 8) on visiting recreational anglers to further support local communities was widely appreciated by village members (N. Gupta, pers. comm. with Misty Dhillon, the Himalayan Outback). However, preventing village members from catching food fish from pools protected by angling associations resulted in village members expressing anxiety about additional recreation angling areas being developed near their freshwater reach without prior consultation (N. Gupta, pers. comm. with village members in Uttarakhand).

4.7.7 Need for science-based adaptive management

There has been a general lack of assessment of the status of recreational fisheries in India. For example, not all registered angling associations have maintained a record of effort, catch, harvest and release rates of fish species. No records are maintained on fishing behaviours (e.g., target species and bait preference) and information available from record books is often scant, with significant gaps between angling seasons (but see Gupta et al., In Press (a); Pinder et al., In Press). Additionally, no scientific studies have been conducted to understand the impacts of recreational fisheries on fish population structure or evaluate impacts of recreational fishing activity in

PAs. Finally, surveys have yet to be conducted to document the potential response from the angling community regarding fixing catch size limits, or closed seasons. Although frequently implemented in North America and Europe (Granek et al., 2008; Hasler et al., 2011), it is important to understand the applicability and potential compliance for such management strategies in India. There is also an urgent need for an adaptive management approach where data gathered and lessons learned from experiences of important stakeholders are shared among management agencies in a systematic way so as to build on management successes (FAO, 2012).

4.7.8 Poor stakeholder engagement

A majority of the anglers surveyed highlighted the lack of government support for recreational fisheries in India, and the need to set up angling conservation units within village communities to ensure that local stakeholders benefit from the industry. Anglers also described concerns about law enforcement, such that persons indulging in illegal fishing practices were seldom arrested and punished by the authorities, as no formal protection strategies for critical fish habitats from anthropogenic stressors occur anywhere in India (see Table 4.6.3). Finally, it was mentioned that more scientific studies were urgently needed to understand the impacts of recreational angling on freshwater biodiversity in India to raise public awareness regarding freshwater ecosystems (see Table 4.6.3).

The ongoing general access conflict between stakeholders, (i.e. angling managements and village members), requires a common platform to bring opposing sides together. The suggestion to set up freshwater fish safe zones on river reaches monitored by local communities could be an ideal solution (Gupta et al., 2014). The spill over effect of fish species from such 'protected' sites could provide both recreational and sustenance opportunities for local stakeholders. Legislative support (central or state level) for recreational angling could provide an overall structure to this leisure activity and highlight its associated benefits (FAO, 2012). However, this has to be linked with ongoing/additional freshwater conservation approaches to control the use of illegal fishing techniques, and introduction of exotic fish species.

4.7.9 Conflict between recreational fisheries and other activities

A majority (87%) of the anglers mentioned that they had witnessed destructive fishing techniques at/near their angling locations, for e.g., the use of explosives such as dynamite, illegal fishing nets, poisons, and electricity. The respondents identified factors such as overfishing, the use of illegal fishing techniques to catch fishes, water pollution, the lack of administrative support from authorities and poor availability of freshwater management strategies, the clearing of riparian habitats, existing and proposed hydro-electric projects, and the introduction of exotic fish species as threats to freshwater ecosystems - most of which have also been recorded in the scientific literature (Dahanukar et al., 2011; Raghavan et al., 2012).

4.7.10 Lack of representative data from the recreational fishery sector

One of the issues facing the recreational fisheries in India is the lack of representative data for the recreational fishery from which to inform management. This is a challenging issue because of the enormous difficulties in sampling people in a developing country where contact by phone, physical address, or online is highly variable by region and state. The widely adopted standard of a telephone-diary survey may be difficult to implement under these conditions; therefore, alternative sampling methods such as face-to-face interviews or angler diaries may need to be explored. Strategies currently being tested in Australia, (i.e. social network sampling without the use of online methods) may be relevant in India, if successful. There are many other potential methods used in health sciences, (e.g. simple random sampling, systematic sampling, stratified sampling, or snowball sampling) that could be applied to difficult to sample populations. There is also a crucial need to involve agencies (i.e. government, fishing organizations, and communities) responsible for funding such surveys. Such an approach has the potential to assist in obtaining representative sample of Indian recreational fishers.

4.8 Realizing opportunities for the future

The survey responses revealed that recreational angling is a male dominated leisure activity in India, mostly attributable to the social structure of Indian society, where sporting activities are mainly indulged in by male members of

the family. However, angling associations could invest in providing opportunities for female associates of visiting anglers and promoting angling locally as a female-friendly activity. This will not only help in promoting the sport among the female population, but could also provide additional benefits to local communities, e.g., cottage industries could benefit from the revenue brought in through ‘angling families’.

In October 2012, a day-long angler’s camp was co-organised by AIGFA for children between the age group of 7-9 years at the WASI lakes in Karnataka. Information relating to different species of fish in the lake, importance of C&R angling for the environment, and an introduction to angling equipment and its assembly was provided to each participant (Derek D’Souza, AIGFA pers. comm.). The large age range of Indian angler respondents who undertook our survey, (i.e., 14-77 years) highlights further opportunities to educate the younger generation about recreational angling.

There is an urgent need to resolve the debate regarding the governance structure and mechanisms for freshwater fisheries management in India, including those related to angling locations. It is often the case that some reaches of a water body are located inside the legislatively-defined boundaries of PAs, and therefore automatically under the jurisdiction of state forest departments. However, forest managers often claim the right to the entire water body, a simmering debate among local stakeholders and forest managers across India. From the forest managers’ point of view, protecting the entire stretch of the water body in question safeguards the reaches within

the PA. This is crucial for the survival of the terrestrial and aquatic species within the PA, as anthropogenic stressors originating outside PA boundaries can have devastating consequences for organisms within PA boundaries (Gupta et al., 2014).

Such divisive actions often give rise to demands for the involvement of the state fisheries departments by local stakeholders. There is a need for both the departments and local stakeholders to reach a consensus, and work in tandem to manage freshwater ecosystems and species. A potential way to achieve this would be to acknowledge village communities as important stakeholders within conservation management plans. The recreational fisheries sector in India is also dependent on the assistance and support from local communities living near the angling locations, thus recreational fisheries associations would do well to incorporate village communities in their planning for the long-term success of their organizations (Gupta et al., In Press (b)).

Among conservation options suggested by respondents, 6% of anglers suggested stocking as a potential conservation approach. It is vital for stakeholders to understand that stocking/ranching is suitable under a particular suite of conditions and may cause a decline in the genetic diversity and reduction in the gene pool if implemented otherwise (Hickley and Chare, 2004; Everard and Kataria, 2011; Pinder and Raghavan, 2013). The IUCN Guidelines for Reintroductions and other Conservation Translocations (IUCN, 2012) explicitly suggest that reintroduction should be beneficial to the

species in question and the ecosystem it occupies, and should only be carried out after scientific research. Therefore, the need to stock fish species merely to increase the catch size or increase the number of catches for recreational anglers should be avoided, particularly as the genetic structure of many target fish populations (including mahseer) are still unknown.

Recreational fisheries management approaches currently applied in India need to be developed to provide long-term ecological, social and economic benefits (Table 4.8). When asked about their willingness to get involved in a conservation initiative in their angling region, a majority (90%) of anglers were willing to get involved, and 76% of the respondents were willing to contribute both their time and money for conservation initiatives. This is an encouraging sign as these resources could be channelled to assist with additional freshwater conservation projects (see Gozlan et al., 2013; Rogers, 2013).

Table 4.8: Recreational fisheries management approaches currently practiced in India (SOURCE: FAO, 2012)

Criteria	Explanation	Current status	Target ecosystem
Licensing and fees	Regulates recreational fisheries	Common	Fresh water and marine
Gear restrictions	Prevents damage to target fish species	Common	Fresh water
Method restrictions	Reduces damage to species and habitats	Uncommon	Fresh water and marine
Closed times, seasons	Less stressful environment conditions during spawning and migration	Common	Fresh water
Closed areas	Protects spawning areas, migration routes	Uncommon	Fresh water
Fishing contests	Overharvests undesirable species	Uncommon	Fresh water and marine
User conveniences	Provides suitable angling locations to attract recreational fishers	Common	Fresh water and marine
Effort restrictions	Limits number of rods per angling site	Common	Fresh water
Length limits	Limits size of fish retained	Uncommon	Fresh water and marine
Bag limits	Limits number of fish retained	Uncommon	Fresh water and marine
Sale of fish	Prohibits commercialization of recreational fish species	Uncommon	Fresh water and marine
Harvest restrictions	Restricts targeting threatened species	Uncommon	Fresh water and marine
Fish holding	Prohibits translocation and stress to species	Uncommon	Fresh water and marine
Harvest mandates	Encourages harvest of undesirable species	Uncommon	Fresh water and marine

4.9 Conclusion

Here I provided the first overview of the status of recreational fisheries in India by combining a traditional literature review with an internet-based social science survey of the angling community in India. There was conservation awareness among the survey respondents (i.e., anglers fishing in India), and

they were willing to support future conservation and management initiatives related to recreational fishing. This is vital as the recreational fisheries sector is in an expansion phase in the country and as an important stakeholder; anglers have the potential to facilitate the conservation of native fish species and their habitats and help facilitate improved livelihoods in rural areas. Monetary incentives have a great potential to motivate local communities to participate voluntarily in angling based tourism, and further assist in the protection of target fish species. However, care needs to be taken to ensure that long term, satisfactory socio-economic benefits are being provided to all participating stakeholders, especially at the local level.

With many freshwater and coastal ecosystems in India threatened by a multitude of anthropogenic stressors, there is a never-ending search for novel and effective management strategies. If provided an appropriate opportunity, recreational fishers as a group could potentially play a key role to realize freshwater fish conservation objectives. To do so will require coordination and cooperation from both grass-roots angling organizations and “top-down” government regulatory agencies. Improving governance and management of recreational fisheries should be a priority, but doing so will require formal commitments and collective willingness to embrace recreational fishing as a legitimate activity. The science needs are immense (e.g., basic natural history, stock assessment, consequences of C&R) but such information is needed to support adaptive management approaches that could lead to a vibrant and sustainable recreational fisheries sector in India

Chapter 5

Assessing recreational fisheries in an emerging economy: knowledge, perceptions and attitudes of catch-and-release anglers in India

5.1 Abstract

Across the globe, catch-and-release (C&R) angling represents a leisure activity indulged by millions. The practice of C&R is commonly advocated by conservation managers because of its potential to protect local fish populations from a range of anthropogenic threats, including over-fishing. In India, C&R angling in freshwaters has a history dating back to colonial times. Despite this, little is known about the current state of the sector. To address this, an online web-based survey was conducted to target C&R anglers who fish in Indian rivers to assess their knowledge, attitudes and perceptions relating to the national status of India's freshwater C&R fisheries. From a total of 148 responses, factors such as angling quality, aesthetics of surroundings, presence of other wildlife, fishery management practices and socioeconomic benefits were evaluated. Over 65% (n=148) of the anglers reported an observed decrease in the quality of fishing (e.g. a reduction in the size and/or numbers of fish available for capture). Respondents also considered deforestation, water abstraction, pollution, hydropower projects and destructive fishing techniques as factors which threaten both the habitat and species they target. C&R practitioners were largely united regarding the

benefits and willingness to contribute both their time and financial input to support conservation initiatives. The current study provides the first overview of the status of C&R angling in India and explores challenges, opportunities, and priorities for future resource management.

5.2 Introduction

Apart from being an important protein source and facilitating vital ecosystem functions (Dugan et al., 2006; Welcomme et al., 2010; Brummet et al., 2013), freshwater fish also provide recreational benefits (Pinder and Raghavan, 2013). Recreational (catch-and-release (henceforth C&R)) fishing, defined as "a non-commercial activity that captures fishes for purposes other than nutritional needs" (Granek et al., 2008; Cowx et al., 2010) is a highly indulged pastime, both in developed and developing countries. C&R has a very high participation rate (Cooke and Cowx, 2004; Granek et al., 2008; Cowx et al., 2010) and its popularity is expected to grow in developing countries and emerging economies owing to increased wealth of their societies (FAO, 2012). For example, despite the popularity of recreational angling in India during colonial times, it is only in the past two decades that C&R angling has gained national popularity, and now represents a fast expanding market (see Everard and Kataria, 2011). Indeed, an increasing number of tour operators are offering angling as part of their wildlife and tourism packages to two of the nation's biodiversity hotspots, the Himalayas and the Western Ghats (Everard and Kataria, 2011). Of particular attraction to international anglers are the mahseers (*Tor* spp.); often considered to be

the world's hardest fighting fish (TWFT, 1984). Both foreign and domestic anglers frequent the upper Ganges catchment (in the Himalayas) and the Cauvery (in the Western Ghats) in pursuit of these fish.

Despite contributing a multitude of key ecological functions and societal benefits (WWF, 2006; Collen et al., 2014), freshwater ecosystems, especially rivers, comprise one of the most endangered and poorly protected ecosystems on earth (Dudgeon, 2011; Cooke et al., 2012). Multiple interacting threats including habitat alteration/loss, alien species, overexploitation, pollution and climate change (Xenopoulos et al., 2005; Dudgeon et al., 2006; Strayer and Dudgeon, 2010; Vörösmarty et al., 2010; McDonald et al., 2011) are widely cited as contributing to the precarious state of global freshwater biodiversity. Since freshwater fishes are integral to ecosystem function and are also a source of food and livelihood to millions (Dugan et al., 2006; Welcomme et al., 2010; Brummet et al., 2013; Reid et al., 2013), they are considered a critical component of freshwater biodiversity. Freshwater fishes are nevertheless one of the most threatened vertebrate taxa on earth (Reid et al., 2013), with more than 36% (of the 5785 species assessed by the IUCN) at the risk of extinction and over 60 species having already gone extinct since 1500 (Carrizo et al., 2013).

Despite varying levels of threat as a result of escalating anthropogenic pressures (Vishwanath et al. 2010; Dahanukar et al., 2011), India supports notably high levels of freshwater fish diversity and endemism. National fishery focused conservation and management policies have often suffered

from setbacks due to jurisdictional issues, oversights, and implementation of top-down approaches (Raghavan et al., 2011); poor enforcement of existing laws (Raghavan et al., 2013) and community-based conservation initiatives often failing to protect river stretches outside their own jurisdiction (Gupta, 2013). Furthermore, the Indian Wildlife (Protection) Act, 1972, the highest legal instrument for wildlife conservation in the country (Dahanukar et al., 2011; Raghavan et al., 2013), affords no mention of freshwater fish. Additionally, very few studies on C&R angling and its potential benefits are available from India (Everard and Kataria, 2011; Pinder and Raghavan, 2013). This study seeks to enhance current understanding of the status of recreational angling by assessing the knowledge, attitudes and perceptions of both international and domestic anglers practicing C&R angling in India.

5.3 Methods

Prior to any data collection a pilot survey was carried out. The questions formulated were based on the concerns and opinions of C&R anglers fishing in India (Pers. comm. with C&R anglers). Randomly selected international and domestic respondents (n=25) from India-specific angling forums were requested to complete the survey and pinpoint any problems with its content (Andrews et al., 2003). A web-based survey was used (running for six months from November 2013 to April 2014) to facilitate quicker response times, increased response rates, and reduced costs (Oppermann, 1995; Lazar and Preece, 1999; Andrews et al., 2003). The survey design was based on a series of 23 questions (see Appendix XI). Information on the

fishing locations and target fish species of interest to anglers was first determined. Further, (a) preferred fishing techniques; (b) factors influencing the angling experience; (c) changes in quality of the angling experience over of the course of angling at a particular location; (d) threats to target species and fishing locations; (e) awareness of the anglers on the conservation status (International Union for Conservation of Nature/IUCN Red List of Threatened Species) of target species; (f) various conservation strategies which the C&R anglers felt was needed for the protection of target species; (g) economics of C&R angling through the amount of money spent (in US$) annually by the anglers on angling and related activities; (h) perception on the benefit of C&R angling as a conservation strategy; (i) willingness to pay for, and get involved in a conservation initiative; and (j) anglers willingness to contribute time and money towards such initiatives was also ascertained. An option for additional comments was also provided at the end of the survey to obtain views and opinions of anglers fishing in Indian waters. Given the concise delivery of questionnaire responses, all responses obtained were pooled under two categories, (i.e. positive and negative responses) for simple representation of data. The percentage of respondents who agreed or disagreed with statements was represented in a tabular form.

To assess international participation, the survey was advertised globally to target anglers spanning different method disciplines. The notification of the survey was posted on global/domestic conservation and angling websites and forums, published in international/national fishing and angling magazines/newsletters, and posted on social media (Facebook, Twitter)

sites. All known India-specific angling forums were also targeted. The survey was advertised every fortnight to maintain interest. No changes were made to the survey questions during the course of data collection (Zhang, 2000) and care was taken to allow only one response per individual angler to avoid dual submission (Hasler et al., 2011) by thoroughly reviewing the responses to spot any duplicate submissions.

Angling quality/experience was defined as the availability of fish (numbers/size) available for capture. The aesthetics of surroundings denoted the environment of the angling location. The presence of other wildlife refers to the visual presence of flora and fauna during angling activities. Fishery management practice considers effort applied by local fisheries/forest department towards the protection and conservation of fish communities. Local stakeholders' involvement and transparent sharing of C&R angling revenue dealt with the engagement of and financial benefits to local communities. Camp infrastructure considers the accommodation available to C&R anglers.

5.4 Results and discussion

A total of 148 responses were obtained and analysed from anglers specifically targeting fishing locations in India, (i.e. United Kingdom/UK + India). In comparison to anglers from the UK, Indian/domestic anglers chose highly diverse and multiple fishing sites distributed across the country (see Table 5.4.1).

Table 5.4.1: Summary of responses obtained from recreational anglers fishing in the Indian rivers

Criteria	UK anglers (n= 40)	Domestic anglers (n=108)
Preferred fishing locations (rivers)	(a) Cauvery: 75% (b) Kali: 6% (c) Ramganga: 19%	Assi Ganga, Barak, Beas, Bhadra, Bhagirathi, Bhakra, Bhatsa, Bhavani, Bhilangana, Bhima, Cauvery, Damodar, Gambur, Ganga, Giri, Godavari, Indrayani, Jaldhaka, Jia Bharali, Kali, Kallada, Kamini, Kosi, Krishna, Manjira, Mula, Narmada, Nira, Pavana, Ramganga, Rangeet, Ravi, Saryu, Shimsha, Subansiri, Sutlej, Teesta, Tirthan, Tons, Tungabhadra, Ulhas, Wardha, Warna and Yamuna
Preferred target fish species	(a) *Tor* spp: 82% (b) *Bagarius bagarius*: 18%	(a) *Barbodes carnaticus, Ctenopharyngodon idella, Gibelion catla, Hypselobarbus* spp, *Oncorhynchus mykiss, Salmo trutta, Schizothorax richardsonii, Labeo calbasu*, *Labeo rohita, Channa marulius, C. striata, Etroplus suratensis, Oreochromis* spp, *and Wallago attu*: 61% (b) *Tor* spp: 26% (c) *Bagarius bagarius*: 13%
Fishing techniques	(a) Bait (live/dead): used (71%); unused (29%) (b) Lure/spinner: used (75%); unused (25%) (c) Fly fishing: used (58%); unused (42%)	(a) Bait (live/dead): used (70%); unused (30%) (b) Lure/spinner: used (83%); unused (17%) (c) Fly fishing: used (22%); unused (78%)
Factors influencing angling experience	(a) Angling quality: agree (100%); disagree (0%) (b) Aesthetics of surroundings: agree (100%); disagree (0%) (c) Presence of other wildlife: agree (92%); disagree (8%) (d) Fishery management practices: agree (94%); disagree (6%) (e) Inclusion of, and financial benefit to local communities: agree (100%); disagree (0%) (f) Camp infrastructure: agree (83%); disagree (17%)	(a) Angling quality: agree (98%); disagree (2%) (b) Aesthetics of surroundings: agree (98%); disagree (2%) (c) Presence of other wildlife: agree (95%); disagree (5%) (d) Fishery management practices: agree (94%); disagree (6%) (e) Inclusion of, and financial benefit to local communities: agree (95%); disagree (5%) (f) Camp infrastructure: agree (89%); disagree (11%)

Criteria	UK anglers (n= 40)	Domestic anglers (n=108)
Changes in quality of angling Experience at the angling locations	Negative change: 75%; positive change: 25%	Negative change: 65%; positive change: 35%
Threats to target fish species and fishing locations	(a) Deforestation: agree (100%); disagree (0%) (b) Water abstraction: agree (100%); disagree (0%) (c) Hydropower projects: agree (100%); disagree (0%) (d) Water pollution: agree (100%); disagree (0%) (e) Destructive fishing techniques: agree (100%); disagree (0%)	(a) Deforestation: agree (91%); disagree (9%) (b) Water abstraction: agree (92%); disagree (8%) (c) Hydropower projects: agree (91%); disagree (9%) (d) Water pollution: agree (97%); disagree (3%) (e) Destructive fishing techniques: agree (96%); disagree (4%)
Awareness regarding conservation status of target species	Aware: 67%; unaware: 33%	Aware: 73%; unaware: 27%
Conservation strategies for target species	(a) Afforestation: agree (100%); disagree (0%) (b) Legislation: agree (100%); disagree (0%) (c) Scientific research: agree (100%); disagree (0%) (d) Anti-poaching patrol: agree (100%); disagree (0%) (e) Harsher fines: agree (100%); disagree (0%) (f) Education: agree (100%); disagree (0%) (g) Stocking: agree (73%); disagree (27%)	(a) Afforestation: agree (98%); disagree (2%) (b) Legislation: agree (96%); disagree (4%) (c) Scientific research: agree (98%); disagree (2%) (d) Anti-poaching patrol: agree (98%); disagree (2%) (e) Harsher fines: agree (97%); disagree (3%) (f) Education: agree (98%); disagree (2%) (g) Stocking: agree (90%); disagree (10%)
Perceptions on angling as a Conservation strategy	Yes: 100%; no: 0%	Yes: 97%; no: 3%
Willingness to pay for and support conservation action	Agree: 86%; disagree: 14%	Agree: 99%; disagree: 1%

Many species targeted by C&R anglers in India have shown a declining trend of population and are listed as threatened in the IUCN Red List, (e.g. *Tor khudree*, *T. malabaricus* and *T*. *putitora*, all assessed as 'Endangered'; the goonch catfish, *Bagarius bagarius* assessed as 'Near Threatened'; and *Schizothorax richardsonii* assessed as 'Vulnerable'), for none of these species has recreational C&R angling so far been mentioned as a threat (see species specific accounts in the IUCN Red List of Threatened Species). This has also been the case with most threatened fish species targeted by recreational anglers around the world (see Cooke et al., in press).

Apart from angling quality, aesthetics of surroundings and camp infrastructure (all directly related to C&R angling experience), ecological factors such as presence of other wildlife, fishery management practices, and the inclusion of, and financial benefits to local communities were valued by C&R anglers (see Table 5.4.1). This not only highlights the ecological and social awareness among C&R anglers, but demonstrates alignment with the current objectives of river and fish conservation policies in the region. Such awareness has the potential to assist in the co-engagement of key stakeholders (Everard and Kataria, 2011) and bridge the gap between social, economic and biological dimensions of river ecosystem conservation (Cowx and Portocarrero-Aya, 2011). Indeed, an opportunity could exist where C&R anglers could become involved in future conservation programmes, and possibly assist in monitoring, data collection, enforcement and lobbying at local levels (Granek et al., 2008; Cowx et al., 2010).

‘Angling quality and experience’ is a key driving force for any C&R angler (Arlinghaus, 2006; Granek et al., 2008). The responses obtained regarding decrease in this experience and quality is a cause of concern not only for ecology and conservation, but also for the human dimensions of the fishery (Hunt et al., 2013). It has been suggested that any conservation assistance from anglers could rely heavily on the satisfactory fulfilment of an angler’s leisure experience (Granek et al., 2008), and that a C&R angler’s ‘angling experience’ depends on the well-being of the fishes they primarily target (Arlinghaus, 2006; Granek et al., 2008). Therefore, a decline in stocks is likely to have a profound effect on the quality of this personal experience, and subsequently impact the overall socioeconomic viability of the fishery (Danylchuk and Cooke, 2011).

The perceptions of UK anglers on the major anthropogenic threats to angling quality (see Table 5.4.1) were consistent with those recorded in the scientific literature (Vishwanath et al., 2010; Dahanukar et al., 2011). However, domestic anglers disagreed with some of the identified threats, (i.e. deforestation: 9%; water abstraction: 8%; hydropower projects: 9%; water pollution: 3%; and destructive fishing techniques: 4%). There could be many possible reasons for this (see Arlinghaus et al., 2007; Hunt et al., 2013) including a) international anglers being more environmentally conscious than domestic anglers, or b) domestic anglers being conditioned to accepting such threats as normal and therefore do not classify them to be such major issues.

A substantial proportion of anglers from both groups (n=148) were unaware of the conservation status (IUCN Red List) of target fish species, (i.e. UK anglers: 33%; domestic anglers: 27%). Strict environmental guidelines for C&R angling, including those that deal with threatened species (see Cooke et al., in press) need to be enforced by the Department of Fisheries and/or the Department of Forest and Wildlife, and also by the angling associations who can influence the behaviour of their members and guests. In addition, voluntary regulations and informal institutions could also play a pivotal role in enforcing guidelines (Cooke et al., 2013).

Both UK and domestic anglers highlighted the strategies required for conserving the target species. These were afforestation, legislation, scientific research; effective anti-poaching patrol, harsher fines and education (see Table 5.4.1). It is important to note that the 'spirit of the river' initiative developed to educate anglers in Mongolia about best-practice catch-and-release techniques for the Taimen (*Hucho taimen*) is an example of how education can also support conservation of threatened species targeted in recreational fisheries (Bailey, 2012). Although there is some legislation (Indian Fisheries Act and various State inland fisheries acts) to protect freshwater fishes in India, effective enforcement is considered to be limited (see Raghavan et al., 2011). The interest of anglers in conserving their target habitats and fish species opens up opportunities for developing participatory enforcement mechanisms based on existing legislations (see Pinder & Raghavan, 2013).

Ninety percent of domestic anglers and 73% of UK anglers agreed in considering the value of ‘stocking’ as a potential conservation tool (Table 5.4.1). Nonetheless, 27% of UK anglers who disagreed with stocking as a conservation strategies for target species expressed awareness of the potential for genetic pollution and the need for decisions on stocking policy to be informed by the historical and current population status of a species within catchments (Hickley and Chare, 2004; Everard and Kataria, 2011; Pinder and Raghavan, 2013). Stocking for angling species has been carried out in major river systems of India (Pinder and Raghavan, 2013), and this could have influenced the responses of domestic anglers. However, comparatively higher awareness among UK anglers could be another reason, as the spread of knowledge regarding the associated issues with stocking of fish species is still in its infancy in India. Indeed, the IUCN Guidelines for Reintroductions and other Conservation Translocations explicitly suggests that reintroduction should be beneficial to the species in question and the ecosystem it occupies, and should only be carried out after focused scientific research (IUCN/SSC, 2013). Hence, stock augmentation for the sole purpose of increasing angler catches (numbers and/or size of fish) should be avoided. This is particularly true of the mahseers for which satisfactory knowledge pertaining to population genetics across India (and beyond) is still lacking (Pinder and Raghavan, 2013).

Along with socio-economic benefits, the efficacy of C&R fishery management in conserving fish populations has been demonstrated in many regions of the world (Arlinghaus, 2006; Granek et al., 2008). Therefore, the high agreement

rate (UK anglers: 100%; domestic anglers: 97%) of anglers that C&R fisheries have the potential to form effective conservation measures was not surprising (see Table 5.4.2).

Table 5.4.2: Dominant responses obtained from C&R anglers (UK + Indian; n=148) regarding the benefits of angling as a tool for conservation of threatened fish species in India

Activity during C&R angling	Benefits to threatened fish species	Reasons
Monitoring	a) Protection against poachers	a) Discourages poaching activities
	b) Helps build recognition for the species	b) Limits poaching
	c) Helps raise conservation awareness among the wider C&R angling community	c) Provides more eyes on the water
	d) Keeps track of fish counts, species diversity and habitat status	
	e) Helps assess the health and quality of the fishery, if applicable	
Prolonged presence along rivers	a) Effective bankside protection	a) Deterrent to poachers
	b) A source of first-hand information on natural and anthropogenic factors affecting fish species	b) More easily accessible information regarding fish species
Revenue generation	a) Future conservation work	a) Local availability of funds
	b) Formation of local anti-poaching patrol parties	b) Economic influence by financially supporting local communities
Involvement of local stakeholders	a) Formation of local groups targeting the conservation of fish species	a) Creation of local job opportunities and training
		b) Local awareness and education
		c) Spreading understanding of the high value of protecting fish species for sustainable recreational purposes
		d) Resulting political influence

Hence, both groups expressed willingness to contribute their time and money to support conservation initiatives within the rivers they fish, (i.e. UK anglers: 86%; domestic anglers: 99%). Willingness to pay (WTP) represents a successful model of protecting fish populations (Gozlan et al., 2013; Rogers, 2013) and enhance recreational fishery performance (Kenter et al., 2013). Added protection of river reaches can also enhance biodiversity and associated ecosystem services (Kenter et al., 2013). The amount of money spent annually towards recreational angling activities (in £) by UK anglers was between 6, 001-9, 000 (modal response), and 1-3, 000 (modal response) by domestic anglers. There is potential for the revenue generated through C&R angling initiatives to feedback to local communities, and further strengthen societal support for future river and fish conservation strategies (Everard and Kataria, 2011). Nonetheless, personal communication with UK anglers (n=7) fishing in Indian rivers has revealed a level of caution regarding the utilization of their 'conservation revenue' recently provided to a few angling managements. Similar views have been expressed by domestic anglers (n=12) (unpublished data). This could be because of a lack of transparency in revenue distribution for species-specific conservation initiatives or local community development by the concerned angling managements. Similar grievances have been recorded previously through interaction with local stakeholders associated with C&R angling activities in the Indian Himalayas (see Gupta et al., 2014). Therefore, for successful utilization of the WTP model and to harness its associated ecological and socio-economic benefits, angling managements foremost need to address the monetary distribution/transparency issue. In addition, rigorous field based

studies need to be conducted to better understand its implementation benefits and associated conflicts of interest among local stakeholders.

5.5 Conclusion

Both UK and domestic anglers fishing in India have demonstrated conservation awareness and a willingness to support local conservation initiatives. This is important as the industry is in an expansion phase in the country, and such collaborative opportunities could assist ongoing and future river and fish conservation strategies. However, there are concerns among C&R anglers that biodiversity managers and policy makers would initiate strict management of C&R angling activities in Indian rivers. This is because there are serious concerns that some C&R anglers cause more risk than benefits to the fish species they target, especially threatened species (Gupta et al., in press). Further, domestic anglers were comparatively unaware of the genetic risks of stocking (see Table 5.4.1). This highlights the importance of spreading awareness through education. This can be facilitated by the existing angling organizations among its members through angling workshops and literature. Additionally, Indian anglers are interested in a much greater diversity of rivers and fish species (see Table 5.4.1). This is a positive sign from a national perspective and demonstrates that C&R benefits beyond mahseer, the Cauvery and Ganges.

Apart from having a current global value in billions (in US$) (FAO, 2012) C&R angling has also generated substantial income for national economies (Cooke and Suski, 2005; Cowx et al., 2010; Danylchuk and Cooke, 2011; Everard and Kataria, 2011). Economic benefits in the year 2005 alone were

estimated at US$2 billion in Canada, US$800 million in New Zealand, US$150 million in Argentina, and US$10-15 million in Chile (Arismendi and Nahuelhual, 2007). The amount of money spent by anglers fishing Indian rivers represents an emerging economy, and could play a decisive role for fish conservation by bringing both social and economic benefits for local communities and associated stakeholders. Everard and Kataria (2011) noted that a single 5-day angling tour for three anglers on the Ramganga River in 2007 generated US$ 1,220; and in 2010 (February-April), US$ 7,800 was spent by anglers in this region on purchases and accommodation alone (Everard and Kataria, 2011). Such monetary incentives could motivate local people to participate voluntarily in fish tourism, and assist in the protection of threatened species from illegal fishing techniques (Everard and Kataria 2011; Pinder and Raghavan, 2013).

As the industry expands, there remains a need to maintain transparency during the profit sharing stages, and ensure the marginalization of any particular group of stakeholders is avoided. C&R anglers frequenting the Indian rivers have expressed concern over the acceptable distribution of angling derived revenue by some angling tourism operators (see Gupta at al., in press). One way to overcome this would be to set up community conservation units (CCUs) within local villages, the members of whom could interact with local angling associations and ensure that appropriate dividends reach their communities. With the current perilous state of Indian rivers and their associated biodiversity, there is an urgent need for alternate

conservation strategies, and C&R anglers as a local stakeholder group could potentially provide such an opportunity.

Catch-and-release angling as a management tool for freshwater fish conservation in India

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Abstract Mahseer are popularly regarded by anglers as the king of freshwater fishes, and are valued across the Himalayan and South-east Asian regions. In India, mahseer are important game fish. Mahseer populations and their habitats face a range of anthropogenic threats, however, including unregulated fishing and habitat fragmentation as a result of hydro-development projects. Catch-and-release angling for mahseer attracts both national and international anglers and could provide information about rivers while generating revenue for regional economies. In this context, we evaluated catch-and-release angling records from rivers that flow within two Indian reserves (the Ramganga and Jia Bharali Rivers in Corbett and Nameri Tiger Reserves, respectively). Golden mahseer *Tor putitora* in the Ramganga and golden and chocolate mahseer *Neolissochilus hexagonolepis* in the Jia Bharali were the most frequently caught fish species. Catch data suggested these game fish populations are probably not negatively affected by angling activities. Interviews with stakeholders highlighted support for catch-and-release angling, mainly because of its perceived economic benefits. The data obtained in this research could potentially assist with both fish conservation and the protection of associated aquatic ecosystems.

Keywords Assam, Corbett, Jia Bharali, Nameri, Ramganga, recreational angling, river conservation, Uttarakhand

Introduction

River fishes provide a range of ecological functions and services. Some species control trophic structure and others indicate the environmental health of a river system (Sarkar & Bain, 2007; Schindler, 2007). Fish provide a protein source for many communities in developing countries (Lakra et al., 2007), offer recreation through catch-and-release angling (Pinder & Raghavan, 2013), and potentially act as flagship species for conservation (Gupta et al., 2014). However, the growing human population and ever increasing demand for water result in water pollution, flow modification, destruction of habitats and invasion by non-native species, and degrading of fish stocks (Everard & Kataria, 2011; Jena & Gopalakrishnan, 2012), and reduce the range and degree of services provided by river fish.

In India fish have not received the same level of conservation attention as more visible, terrestrial species (Pinder & Raghavan, 2013). Policies for fish conservation have suffered from formulation and implementation delays as a result of poor management practices (Sarin, 2005; Ribot & Agrawal, 2006), and community-based conservation has struggled to protect rivers outside village jurisdiction (Gupta, 2013). At a federal level, no freshwater fishes are listed in the Schedules of Protected Species in the Indian Wildlife (Protection) Act, 1972 (Sarkar et al., 2008). There is a clear need, however, to formulate and implement conservation strategies to protect freshwater fishes and their habitats (Pinder & Raghavan, 2013).

Catch-and-release angling (i.e. capturing using rod and reel, and releasing fish, as a leisure activity) could be widely offered through region-specific environmental guidelines. This type of angling is a popular leisure activity and could provide benefits to local stakeholders (Pereira et al., 2008). For example, a 5-day angling tour for three anglers on the Ramganga River, India, in 2007 generated USD 1,220, and in the same location in 2010 anglers spent USD 7,800 on food and accommodation (Everard & Kataria, 2011). Catch-and-release angling also generates income for other national economies. In Alaska catch-and-release angling generates USD 1 billion annually (Zwirn et al., 2005). Catch-and-release angling for the yellowfish (*Labeobarbus* spp.) in the Orange Vaal River, South Africa, is valued at USD 160 million annually (Impson et al., 2008). In the right setting, the provision of catch-and-release angling is a stable and profitable undertaking (Arismendi & Nahuelhual, 2007).

Along with economic benefits, catch-and-release angling can enhance conservation (Arlinghaus, 2006; Granek et al.,

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Received 26 May 2014. Revision requested 2 July 2014.
Accepted 29 August 2014.

2008; Pinder & Raghavan, 2013). For example, the Deccan mahseer *Tor khudree* populations in the Cauvery River, South India, are protected by associations among local stakeholders and catch-and-release anglers (Pinder & Raghavan, 2013). Catch-and-release anglers can also provide important information to assist conservation via reporting of fishing effort and data on fish caught (e.g. species identifications, individual length & mass), which are typically recorded in logbooks kept by fishing clubs and individual anglers (McGarvey et al., 2005; Cooper, 2006). Such data can also aid scientists and policy makers in the design of management actions.

Mahseer are of angling interest because of their renowned fighting abilities and are regarded by anglers as the king of freshwater fishes (mahseer refers to fish of the genera *Tor*, *Neolissochilus* and *Naziritor* in the family Cyprinidae). Two popular mahseer in India, the golden mahseer *Tor putitora* and chocolate mahseer *Neolissochilus hexagonolepis*, face threats from activities such as poaching and the construction of barrages and dams (Nautiyal et al., 2013; Pinder & Raghavan, 2013). These species receive some protection, however, in the Ramganga and Jia Bharali Rivers in the Indian Himalayan region where the rivers flow through the Corbett and Nameri Tiger Reserves.

The aim of this research was to examine the potential of catch-and-release angling as a monitoring and management tool for the protection of mahseer in the Ramganga and Jia Bharali rivers. These rivers were of special interest because they are within the legislatively defined boundaries of tiger reserves and may thus receive indirect protection, and there are recreational catch data for 1999–2012 for both rivers. Our specific objectives were to evaluate catch-and-release data for mahseer species, and to investigate the opinions of stakeholders towards catch-and-release angling and its potential as a management tool.

Study area

The Ramganga is a perennial river originating at 800–900 m altitude in the north-west of Almora district in Uttarakhand. In 2004 local angling associations obtained a lease from the Uttarakhand Forest Department for a 24 km length of the Ramganga River within Corbett Tiger Reserve. The goal of the angling associations was to protect mahseer populations through catch-and-release angling. During 2004–2011 catch-and-release angling increased on the Ramganga, attracting both national and international anglers, resulting in economic benefits for some local stakeholders (Everard & Kataria, 2011). In July 2012 catch-and-release angling within all protected areas was halted by the Supreme Court of India (Ajay Dubey vs National Tiger Conservation Authority (special leave petition no(s).21339/2011)). The order was to safeguard tiger *Panthera tigris* habitats by halting human activities within tiger reserves. The catch-and-release angling associations located on the Ramganga were directly affected as all angling was banned within the boundaries of Corbett Tiger Reserve. However, catch-and-release angling is still permitted on reaches of the Ramganga River outside Corbett Tiger Reserve, and this is where the majority of foreign and Indian anglers visiting the region now fish.

The Jia Bharali is a major tributary of the Brahmaputra River, with c. 30 km lying within the Nameri National Park. Catch-and-release angling permits were issued for the river through the Assam (Bhoralli) Angling and Conservation Association. As on the Ramganga, all catch-and-release angling was banned within the Park boundary in 2012.

Methods

Catch data for fish caught by national and international catch-and-release anglers during 1999–2012 were obtained from the logbooks of angling associations on the Ramganga and Jia Bharali Rivers. The logbooks include total number and weight of fish caught (Table 1) and unsuccessful angling events. Catch-and-release angling events generally lasted for 1 hour, whether successful or not (catch-and-release angling guides, pers. comms). In all cases these data were willingly provided by the angling associations (the Mahseer Conservancy and the Himalayan Outback on the Ramganga River, and the Assam (Bhoralli) Angling and Conservation Association on the Jia Bharali River).

The catch per unit of fishing effort (CPUE; number of fish caught/number of hours angling) was calculated for the most frequently landed fish. A one-way ANOVA was used to test whether there were differences in CPUE and mean weight of individual species across years. It was not possible to assess differences between rivers because of gaps in the data for individual species and annual variations in fishing effort on the Jia Bharali River.

We conducted semi-structured interviews with stakeholders near Corbett Tiger Reserve and the Ramganga River during 2012–2013. Interviews were not conducted in Nameri Tiger Reserve because of logistical constraints. The aim of these interviews was to explore themes related to catch-and-release angling, in particular conservation benefits for fish, the availability of economic incentives, and conservation concerns. Interviewees were identified as conservationists (individuals generally opposed to angling, blaming it for harming river habitats and wanting to see stricter enforcement of guidelines for angling), people directly associated with angling (Indian catch-and-release anglers and catch-and-release angling association workers) or local people (residing along the Ramganga River). The interviewees were sampled based on their availability during the

TABLE 1 Summary of catch records from the catch-and-release angling log books of the Mahseer Conservancy, Himalayan Outback and Jia Bharali angling associations for the Ramganga and Jia Bharali rivers, with the total number of golden mahseer *Tor putitora* landed, total number of hours spent angling, catch per unit effort (CPUE), and total number of other fish landed (including chocolate mahseer *Neolissochilus hexagonolepis*).

	Ramganga River				Jia Bharali River			
Year*	No. of golden mahseer	No. of hours angling	CPUE	No. of other fish	No. of golden mahseer	No. of hours angling	CPUE	No. of other fish
1999–2000					18	107	0.17	62 chocolate mahseer, 7 *Raiamas* spp.
2000–2001								
2001–2002								
2002–2003					12	38	0.33	14 chocolate mahseer
2003–2004					30	67	0.45	7 chocolate mahseer
2004–2005	12	28	0.43	0				
2005–2006	4	18	0.22	0				
2006–2007	12	47	0.26	0				
2007–2008	3	18	0.17	3 *Bagarius* spp., 2 *Labeo* spp.				
2008–2009	6	24	0.25	2 *Bagarius* spp.	14	43	0.33	6 chocolate mahseer, 9 *Raiamas* spp.
2009–2010	16	46	0.35	0	53	142	0.37	22 chocolate mahseer, 10 *Raiamas* spp.
2010–2011	47	102	0.46	0	44	134	0.33	43 chocolate mahseer, 3 *Raiamas* spp.
2011–2012	37	74	0.50	1 *Tor* spp., 1 *Bagarius* spp., 1 *Bangana* spp.	7	28	0.25	2 chocolate mahseer, 2 *Wallago* spp.

*The angling months of October–June, the peak angling season on these rivers before the arrival of the monsoon rains

field survey, their willingness to participate, their residence in villages near the Ramganga River, and whether they had an association with local catch-and-release angling. The total number of responses obtained for each group depended on the approachability of individuals and their availability and willingness to participate. The 15–30 minute interviews were conducted during 9.00–17.00.

The research was first explained to the each participant. Issues such as security, access and privacy of collected data were explained to each respondent. The interviewees chose whether to participate. Care was taken to allow respondents to express their opinions, and leading interviewees to an answer was avoided. The responses obtained from interviewees were recorded under the themes of conservation benefits, economic incentives and conservation concerns.

Results

Catch data

Two hundred records (147 fish landed and 53 unsuccessful angling events in a total of 357 hours of fishing) for 2004–2012 were obtained from the logbooks of the two angling associations on the Ramganga River. Fish landed included the golden mahseer, *Bagarius* spp., *Labeo* spp. and *Bangana* spp. (Table 1). For golden mahseer, mean annual CPUE ranged from 0.17 (2007–2008) to 0.50 (2011–2012) but there was no significant difference ($P = 0.43$) across years, and weight landed (Fig. 1a) was 680–4,000 g (Table 1) and not significantly different across years ($P = 0.44$).

Three hundred and ninety records (365 fish landed and 25 unsuccessful angling events in a total of 559 hours of fishing) for 1999–2012 were obtained from the logbooks of the angling association on the Jia Bharali River. Fish landed included the golden and chocolate mahseers, *Raiamas* spp. and *Wallago* spp. (Table 1). For golden mahseer, mean annual CPUE ranged from 0.17 (1999–2000) to 0.45 (2003–2004; Table 1) and was significantly different across years ($P = 0.03$), and weight landed (Fig. 1b) was 2,400–7,000 g and significantly different across years ($P = 0.03$). For chocolate mahseer, mean annual CPUE ranged from 0.07 (2011–2012) to 0.58 (1999–2000; Table 1) and was significantly different ($P = 0.001$) across years, and weight landed (Fig. 1c) was 2,200–4,500 g and significantly different ($P = 0.02$) across years.

Stakeholders' views

A total of 84 individuals (20 conservationists, 19 Indian catch-and-release anglers, 22 catch-and-release angling

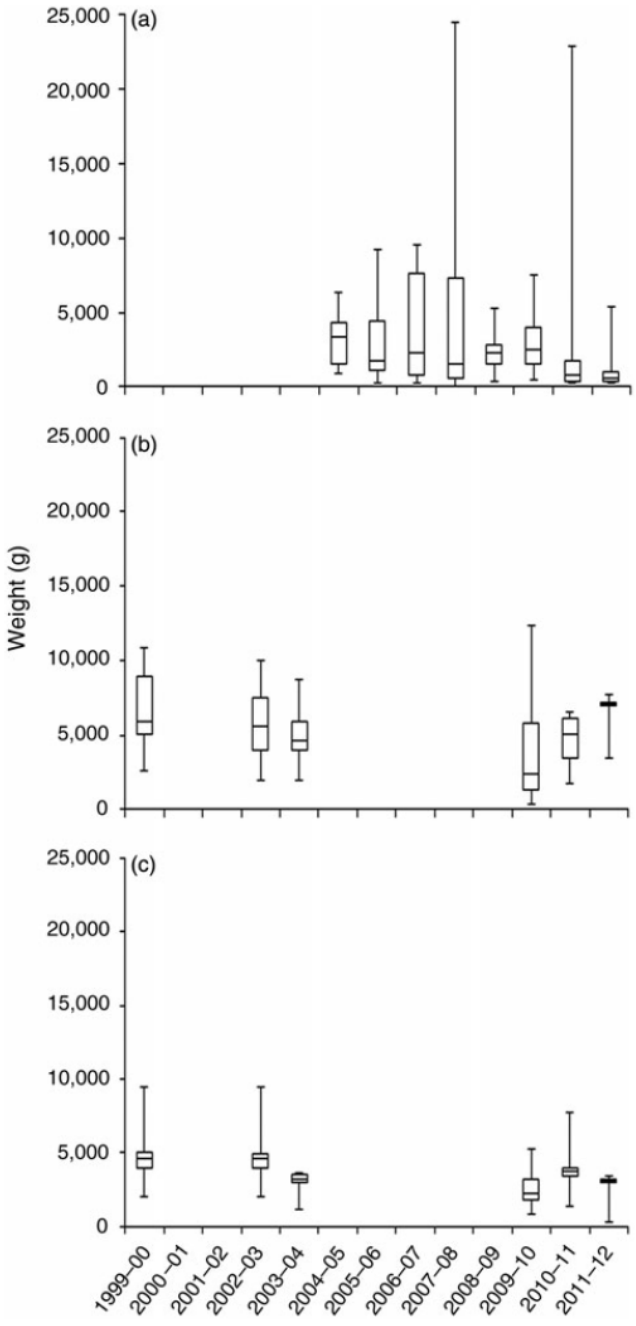

FIG. 1 Box-and-whisker plots of the weight of (a) golden mahseer *Tor putitora* caught during 2004–2012 on the Ramganga River, and (b) golden mahseer and (c) chocolate mahseer *Neolissochilus hexagonolepis* caught during 1999–2012 on the Jia Bharali River (the box contains the first and third quartiles and the band is the median, and the whiskers indicate the minimum and maximum values). Although the angling logbooks contained catch data for 2008–2009 for the golden and chocolate mahseer in the Jia Bharali river (Table 1) the data did not include the weight of individual fish, hence there are no box-and-whisker plots for this year in (b) and (c). A year is the angling months of October–June, the peak angling season on these rivers before the arrival of the monsoon rains.

association workers, and 23 local residents) were interviewed. Their views are summarized in Table 2 under three themes.

Conservation benefits Fifty percent of conservationists indicated there was limited protection for fish but suggested that the presence of catch-and-release anglers deterred the use of illegal fishing methods such as dynamiting and poisoning. The other 50% of conservationists did not comment on this issue, either because of their lack of engagement with catch-and-release angling or because they did not wish to support the activity openly (as stated by them). All catch-and-release anglers indicated that catch-and-release angling was beneficial for mahseer and other fishes. Individuals in this group stated that economic opportunities generated through catch-and-release angling had brought together stakeholders, including local people. Anglers were also positive about how angling raises the profile of some fish, particularly golden mahseer. Amongst angling association workers, 82% indicated that catch-and-release angling had been crucial for the survival of mahseer (as angling prevented illegal fishing, which continued to occur upstream of angling locations), and 18% stated that the involvement of local stakeholders was critical for sustaining this approach. Amongst village members, 87% indicated that patrolling and guarding of river reaches had provided protection for the mahseer but 13% indicated that river reaches upstream from angling sites required urgent attention to ensure successful river and fish conservation.

Economic incentives Amongst conservationists, 75% acknowledged that monetary benefits were provided to some local communities but 25% stressed that more money should percolate into local communities to secure support from stakeholders. All catch-and-release anglers indicated that local employment opportunities (e.g. catch-and-release angling guides, cooks, porters, cleaners) and economic benefits (e.g. through catch-and-release angling revenue) had increased substantially as a result of catch-and-release angling. Similarly, all association workers indicated there was considerable income for local people involved in catch-and-release angling, and there was a flow of revenue to local communities located near catch-and-release angling locations. Amongst village members, 83% indicated there were economic benefits to some village members (e.g. guides) but stressed they were not satisfied with the amount of money reaching their communities (although 17% indicated that this amount was better than nothing).

Conservation concerns Amongst conservationists, 50% indicated that although catch-and-release angling provided monetary incentives for local stakeholders, some inexperienced anglers visiting the region were causing harm to the river ecosystem (e.g. destroying vegetation to reach suitable angling sites) and to the fish (e.g. using unsuitable hooks, and long and poor handling of landed

TABLE 2 Summary of the views of four groups of local stakeholders on the conservation benefits and economic incentives of, and conservation concerns for, catch-and-release angling on the Ramganga River.

Criteria	Conservationists (n = 20)	Indian catch-and-release anglers (n = 19)	Angling association workers (n = 22)	Local residents (n = 23)
Conservation benefits	Presence of catch-and-release anglers on river prevents illegal fishing; some preferred not to comment	Catch-and-release angling beneficial for all fish species; economic opportunities bring key stakeholders together; catch-and-release angling raises profile of target fish species	Catch-and-release angling crucial for survival of mahseer species; dynamite fishing prevented at angling sites; local stakeholders' involvement critical for conservation	Regular patrolling & guarding of river reaches provides protection to all fish species; upstream reaches of rivers need attention to sustain long-term conservation
Economic incentives	Some monetary benefits provided to local communities; more money from catch-and-release angling should percolate into communities, to help secure support	Local employment opportunities & economic benefits	Considerable income for local people involved in angling activities; revenue for local communities based near angling locations	Economic benefits to some village members; low satisfaction with amount of money reaching communities; the money available for local communities is better than nothing
Conservation concerns	Some inexperienced anglers causing harm to river ecosystems; lack of conservation awareness among some catch-and-release anglers	Illegal fishing techniques harming fish species, with sustainability of angling under threat; more patrolling by concerned authorities required, & harsher punishments	Use of dynamite for catching fish damaging river ecosystems; perpetrators need to be brought to justice	Pressures on upstream river reaches needs attention; tougher penalties to deter illegal fishing techniques; spreading conservation awareness of river ecosystem, targeting local communities living along rivers

fish). Other conservationists were concerned with the absence of an appropriate attitude to conservation (e.g. lack of awareness of the target species) among some catch-and-release anglers. All catch-and-release anglers indicated that use of illegal fishing techniques was harming fish and threatening the sustainability of angling activities in the region. They wanted more patrolling by forest officials and harsher punishments for offenders. All association workers indicated that the use of dynamite for catching fishes was damaging river ecosystems, and that those responsible should be prosecuted. Amongst local residents, 70% stated that unless pressures to upstream river reaches could be contained they would struggle to conserve downstream reaches, 13% believed that tougher penalties could deter the perpetrators, and 17% felt that awareness about river ecosystems should be encouraged by targeting local communities living beside rivers.

Discussion

Catch data recorded in logbooks are an inexpensive source of fishing data, especially in areas where regular scientific surveys have not been possible (Bishop et al., 2008; Sampson, 2011). Logbooks can also be a valuable source of data on the spatial distribution and amount of effort involved in fisheries (McGarvey et al., 2005; Cooper, 2006). Catch data from logbooks for catch-and-release angling on the Ramganga River showed that the interquartile range of the weight of golden mahseer decreased from 2010 to 2012 (Fig. 1a). On the Jia Bharali River there was a stable catch weight of both golden and chocolate mahseer during 2009–2012 (Figs 1b,c) but the interquartile range of weight varied during years and was smallest in 2011–2012, probably as a result of the decreased catch in these years (Table 1). However, with significant differences in CPUE and fish weight (also probably driven by annual variation in effort) during 1999–2012, there were no discernible patterns suggesting stable fish populations on the Jia Bharali River.

Although these data can provide information on fish population dynamics the data cannot be used to estimate population size. Therefore there are ongoing efforts to estimate population sizes of mahseer on the Ramganga River (N. Gupta, unpubl. data). The combination of quantitative population estimates and data from recreational catches can provide monitoring data and facilitate a citizen-science based approach for mahseer conservation (Bonney et al., 2009).

The robustness of the catch data from the catch-and-release angling association logbooks could be questioned (Walsh et al., 2005; Marriott et al., 2013). However, despite the limitations of these data (Mosindy & Duffy, 2007; Jansen et al., 2013) there are no reasons for the catch-and-release anglers to report data incorrectly. These data were recorded

voluntarily and were not being collected for either management or stock assessment (Sampson, 2011), and logbooks are maintained by catch-and-release angling associations primarily to monitor whether target fish species are likely to be present at angling sites. The accuracy of these data ensures a sustainable catch-and-release angling business.

The incorporation of local stakeholders is widely accepted as vital for the success of conservation (Granek et al., 2008), and engagement of and support from local stakeholders is crucial for the success of river conservation policies (Everard & Kataria, 2011). More importantly, stakeholder participation in locally targeted conservation projects has the potential to protect fish (Pinder & Raghavan, 2013). We found that conservationists were sceptical that catch-and-release angling associations could contribute to the protection of fish species, although some of the interviewees suggested that the presence of catch-and-release anglers on river banks discouraged illegal fishing practices. There was overall agreement amongst conservationists that if environmental rules are observed during catch-and-release angling, this activity could play an important role in fish conservation.

It was stressed by a majority of the interviewees that more profits from catch-and-release angling should reach local communities. To gain support from conservationists (which is key for the transfer of knowledge), catch-and-release angling associations need to follow the guidelines for angling, and address the issue of improved profit-sharing for local communities.

The catch-and-release anglers emphasized that angling was advantageous to mahseers and to other fish species. Anglers believed this was because of the apex, ecological role of mahseer species in river ecosystems. It was added that catch-and-release angling had demonstrated the ability to bring key local stakeholders together whilst also raising the profile of game fish. Nevertheless, catch-and-release anglers wanted more patrolling by authorities, for controlling illegal activities and to help sustain catch-and-release angling.

Local people were concerned that upstream river stretches required improved protection to facilitate the conservation of the river stretches used for angling. The sympathies of this group towards conservation indicates their importance as stakeholders for river conservation. However, the concerns of some local people regarding profit sharing need to be examined by the catch-and-release angling associations, to ensure the long-term support of the local residents.

Despite the benefits it has been suggested that, in general, angling negatively affects fish communities and aquatic food webs and ecosystems (McPhee et al., 2002; Cooke & Cowx, 2004; Arlinghaus, 2006; Granek et al., 2008). However, we believe that any shortcomings of catch-and-release angling depend on the history, laws, culture and economic environment of a country (Arlinghaus et al., 2007), and ecosystem management should take into account the benefits available from an ecosystem and how best to harness them for conservation strategies (Arismendi & Nahuelhual, 2007) through economically viable use of natural resources (Zwirn et al., 2005). It is important to note that the angling experience of catch-and-release anglers depends on the well-being of the fishes they target (Arlinghaus, 2006; Granek et al., 2008). Any decline in target species will have an effect on the quality of the angling experience. More importantly, the economic viability of the angling industry is imperilled by threats to rivers and fish (Danylchuk & Cooke, 2011), and therefore there has been a surge in collaborative approaches between catch-and-release anglers and stakeholders, often giving rise to successful fish conservation (Granek et al., 2008; Pereira et al., 2008; Cowx et al., 2010).

Although the mahseer species targeted by catch-and-release anglers are categorized as threatened on the IUCN Red List, catch-and-release angling is not recorded as a threat in the species accounts. There is potential for catch-and-release angling to be a monitoring tool for fish conservation in India and elsewhere. Catch-and-release angling offers economic opportunities to local stakeholders and provides incentives for resource protection and maintenance of ecological integrity. It also helps generate local support through capacity building and sustainable development (Granek et al., 2008; Pinder & Raghavan, 2013), and contributes to conservation by providing data (i.e. catch statistics, environmental monitoring) whilst also being a tool for the conservation of rivers and fish.

Acknowledgements

We thank the Directors and District Forest Officers of Corbett Tiger Reserve and Rajaji National Park for permissions, Sumantha Ghosh and Misty Dhillon for help with fieldwork, and Vinod Belwal, Sanjeev Paroriya and Assam (Bhoralli) Angling and Conservation Association. This study was funded by King's College London, UK.

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Biographical sketches

Nishikant Gupta is interested in river and fish conservation in India. Prakash Nautiyal's interests include conservation of mahseer species, and aquatic biodiversity and flow assessment for Himalayan Rivers. Atul Borgohain is interested in the potential of angling tourism in India. K. Sivakumar's interests include fish and avian ecology, island ecology, marine biology, invasive species and Antarctic wildlife. Vinod Mathur's interests include biodiversity conservation, environmental and strategic impact assessment, biodiversity informatics and natural heritage conservation. Michael Chadwick's interests include understanding how ecosystem structure and function respond to changes in environmental conditions.

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Area, 2014, doi: 10.1111/area.12124

The 'tiger of Indian rivers': stakeholders' perspectives on the golden mahseer as a flagship fish species

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Revised manuscript received 26 June 2014

Promoting a fish as a flagship species (i.e. a charismatic animal that promotes awareness) is a management tool to improve the effectiveness of conservation measures. However, to be successful this approach requires strong stakeholder support. To investigate the feasibility of the flagship species approach and degree of stakeholder support in India, semi-structured interviews were conducted with forest managers, anglers and village members in Uttarakhand. Stakeholders were supportive of the flagship approach and the golden mahseer was favoured because of economic benefits associated with recreational angling.

Key words: *Himalayas, conservation, rivers, national parks, mahseer*

Introduction

Freshwater fish populations and communities throughout India are facing environmental pressures due to stressors, e.g. land-use change and increased demands for water (Saunders *et al*. 2002), associated with a growing human population (Sarkar *et al*. 2008 2013). Water pollution, channelisation and regulation of river flows have all negatively affected Indian rivers and fish biodiversity (Ahmad *et al*. 1990; Le Pichon *et al*. 2006). Compounding these environmental issues, variation in monsoonal pattern potentially influenced by climate change can affect fish populations (Dudgeon *et al*. 2006; Nguyen and Silva 2006; Nel *et al*. 2009). Despite the awareness of these threats to Indian rivers, there has been limited protection for freshwater fish. For example, the Indian National Bureau of Fish Genetic Resources (2010) identified over 100 freshwater fish species as threatened, but none are listed in the Indian Wildlife Protection Act, 1972 (Sarkar *et al*. 2008 2013).

Flagship species or charismatic animals that promote environmental awareness can be an important conservation tool (Caro and O'Doherty 1999; Barua *et al*. 2011). For example, tigers (*Panthera tigris*) have been designated as protected in India since 1973 and conservation efforts have improved tiger survival to an extent while simultaneously facilitating the protection of large areas of forest habitat (Post and Pandav 2013). The management linked to tigers has also helped to maintain associated biodiversity within protected areas (Johnsingh and Joshua 1994; Rastogi *et al*. 2013). The recent Fifth National Report on Biodiversity of the Government of India to the Convention for Biological Diversity (2014) highlights the success of some flagship species conservation programmes in India, especially of tigers, rhinos (*Rhinoceros unicornis*) and sangai (*Rucervus eldii eldii*). However, some argue that 'Project Tiger' may have failed to protect all species occurring in India, but that it has helped to conserve many species and habitats in the wider landscape. Several riverine fish species in South America, such as tambaqui (*Colossoma macropomum*), and Indonesia, such as clown loach (*Botia macracanthus*), have played flagship conservation species roles (Dudgeon 2000). Therefore, assigning flagship status to a carefully selected fish species could be beneficial for Indian rivers more widely.

The success of flagship species relies on both the species' potential to increase awareness and the associated social and economic benefits (Lorimer 2006). Engaging local stakeholders by conveying an awareness of benefits associated with flagship species may create

widespread support and acceptance for this conservation strategy (Linnell *et al*. 2000; Barua *et al*. 2012). Further, understanding of local stakeholders' motivation can also ensure effectiveness of conservation efforts which focus on one or a few species (Barua *et al*. 2011; Root-Bernstein and Armesto 2013; Kanagavel *et al*. 2014). This is because attitudes towards wildlife are often a mixture of economic, consumptive and cultural rationales and local stakeholder groups can have a strong influence on attitudes toward flagship species (Kanagavel *et al*. 2014).

Beyond stakeholders' views, designating flagship species generates wider support for conservation, particularly if actions protect threatened species. Examples of successful adoptions of this approach include Ujung Kulon National Park for Javan rhinoceroses (*Rhinoceros sondaicus*) (Caro *et al*. 2004); the Sangay National Park for the mountain tapir (*Tapirus pinchaque*) (Clucas *et al*. 2008; Downer 1996); and the Rajaji and Corbett National Parks for the Asian elephant (Johnsingh and Joshua 1994; Clucas *et al*. 2008). In each case, flagship species have raised environmental awareness and assisted in fund-raising activities (Caro and O'Doherty 1999; Bowen-Jones and Entwistle 2002; Caro *et al*. 2004; Clucas *et al*. 2008; Dalerum *et al*. 2008). Flagship species can also work beyond individual protected areas. For example, giant pandas (*Ailuropoda melanoleuca*), tigers and African elephants (*Loxodonta Africana*) have been instrumental in promoting conservation policies to a large audience (Bowen-Jones and Entwistle 2002). Further, many conservation organisations use flagship species for brand identification which significantly helps with fund-raising activities (Clucas *et al*. 2008).

Focusing on one species has not always been successful for conserving biodiversity (Andelman and Fagan 2000), although the use of flagship taxa is not really about one species, but rather a way to draw attention to wider issues. Flagship species at the very least promote environmental education, which can support wider ranging conservation efforts. In the Indian context, tigers and Asian elephants are success stories to varying extents (Post and Pandav 2013; Rastogi *et al*. 2013). This paper focuses on the conservation of rivers in the Himalayan region using fish as a flagship species. Selection of such fish needs to include local stakeholders' perceptions, attitudes and association with the species (Bowen-Jones and Entwistle 2002; Farjon *et al*. 2004). Fish that provide additional social and economic benefits among local stakeholders or that already have international recognition (e.g. trophy game fish) are therefore probably the best candidates.

Study area

The research was undertaken in the vicinity of Corbett National Park and Rajaji National Park in Uttarakhand, India. Corbett National Park was India's first tiger reserve (Singh *et al*. 2009) and Rajaji National Park was crucial for the protection of the elephant population in the region (Johnsingh and Joshua 1994). The major rivers in the study areas include the Ramganga, the Khoh and the Kosi (Figure 1).

Methodology

Semi-structured interviews were conducted with a range of local stakeholders. The respondents selected for the interviews included forest managers, Indian catch and release anglers (henceforth C&R anglers) and local village members living in close proximity to rivers (Figure 1). The villages were chosen based on their proximity to sites where threatened fish species were recorded during previous fish surveys (see Figure 1). Selected stakeholders were given a choice to participate; interviews followed a conversational approach and typically lasted between 15 and 30 minutes. Five key themes were explored during the interviews: (a) perceptions of threatened fish of the region; (b) traditional and cultural associations with identified fish; (c) unique features of identified fish; (d) social and economic benefits associated with fish conservation; and (e) suggestions for improved river conservation.

The interview process was supported by the use of a checklist containing locally threatened fish species (Table 1). The flagship species concept was explained to each participant and then they were asked to identify fish that they would promote as a flagship species. This approach also allowed the exploration of participants' perceptions towards locally threatened species. During the interviews, we assessed views on how flagship fish could promote conservation and tourism, and raise local awareness of degraded river ecosystems. Material collected during interviews relating to potential flagship fish were grouped into four major categories (i.e. traditional and cultural association, unique features, social and economic benefits and other observations). These summarised responses were then aggregated among stakeholder group types (see above). Finally, we qualitatively assessed responses for all suggested flagship species using methods adapted from Bowen-Jones and Entwistle (2002) and Farjon *et al*. (2004). Briefly, our modified method evaluated a range of parameters (i.e. geographical distribution, conservation status, ecological role, recognition, existing usage, charisma, cultural significance, positive associations, local knowledge, local names, scientific value and utility) to create a multifactor assessment of the potential for each fish species to fulfil the flagship species role.

Results

In total 179 semi-structured interviews were conducted. Participants included forest managers (e.g. wardens,

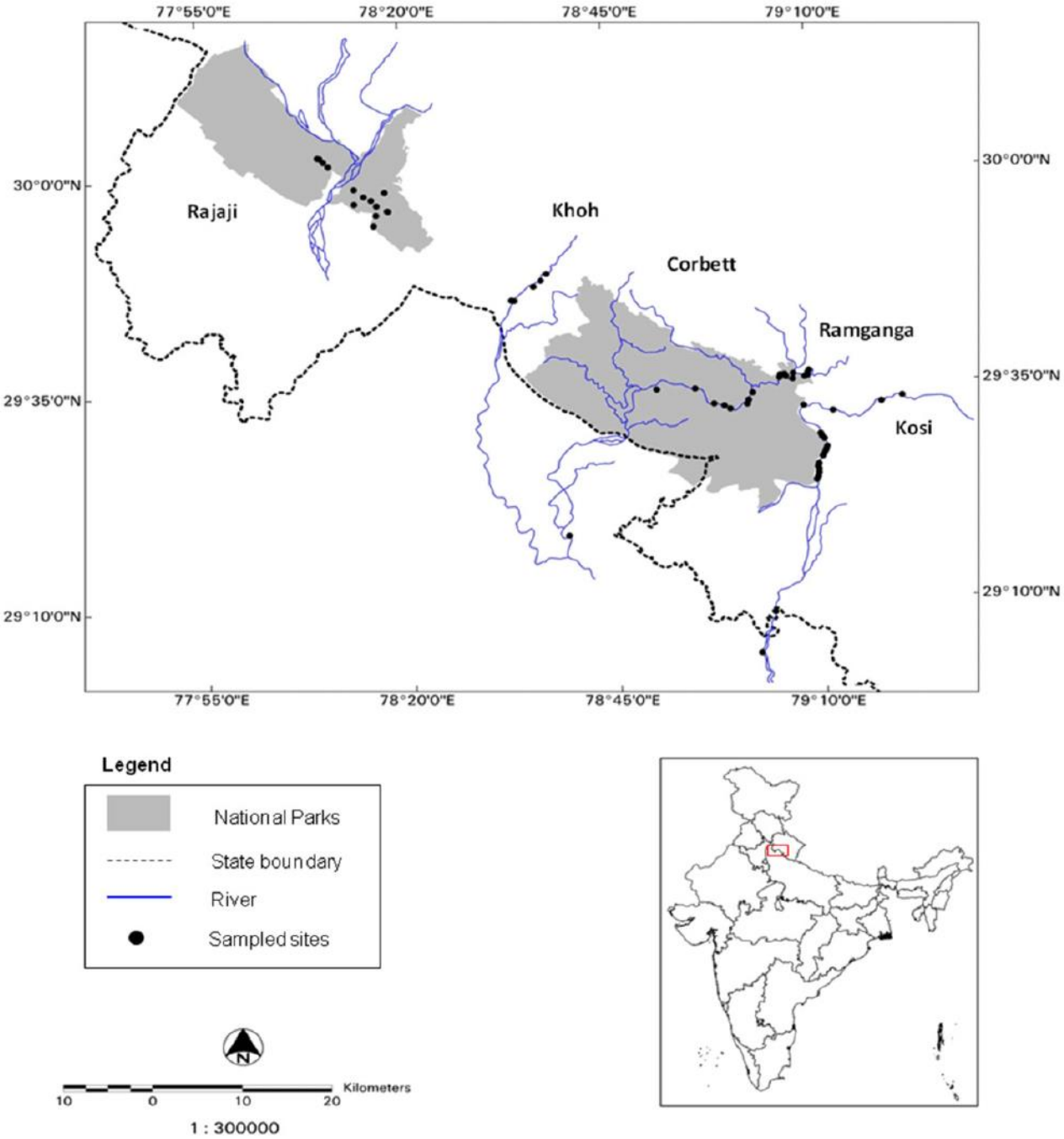

Figure 1 Study area showing the Corbett and Rajaji National Parks in Uttarakhand. Also shown are the Kosi, Ramganga and Khoh rivers

Note: The black dots represent the village locations and sampled sites where threatened fish species have been collected
Source: N. Gupta unpublished data

rangers, patrol guards; n = 21), C&R anglers (n = 18), and local people living alongside rivers (n = 140). Participants' were aged between 18 and 65 years and a total of 161 men and 18 women were interviewed.

Twenty-six individuals (15%) selected rosy barb (*Pethia conchonius*) for its beautiful red colour, and 133 individuals (74%) selected the golden mahseer for its large size, golden colour and potential role as a revenue-generator in

Table 1 Summary of perception of interviewees (dominant response) towards individual fish species identified during previous surveys

Order	Family	Species	Common name	Flagship species	Reasons
Cypriniformes	Balitoridae	*Schistura montana*	Loach	No	Small in size
	Cobitidae	*Botia lohachata*	Y-loach	No	Beautiful, but won't achieve purpose
	Cyprinidae	*Bangana dero*	Kalabans	No	Local food source; no charm
		Barilius barila	Barred baril	No	Small in size; not attractive
		Barilius schacra	Schacra baril	No	Small in size; not attractive
		Barilius vagra	Vagra baril	No	Small in size; not attractive
		Garra gotyla	Gotyla	No	No local use
		Pethia conchonius	Rosy barb	Yes	Very beautiful
		Puntius chelynoides	Dark mahseer	No	Prefer *T. putitora*
		Puntius vittatus	Kooli barb	No	Prefer *P. conchonius*
		Schizothorax richardsonii	Alwan snowtrout	No	Not attractive
		Tor putitora	Golden mahseer	Yes	Attractive; large size; locally found; intelligent and difficult to catch; generated revenue through catch-and-release angling
		Tor tor	Tor mahseer	No	Prefer *T. putitora*
Siluriformes	Sisoridae	*Bagarius bagarius*	Gangetic goonch	No	Rarely seen these days

Source: Atkore *et al*. (2011)

association with C&R angling (see Table 1). Interestingly, 20 village individuals (11%) did not prefer any species as a potential flagship and were doubtful of its success and believed that conservation was the responsibility of the Central Government.

Fifty-two per cent of the forest managers added that the golden mahseer was the pride of the area. This was considered a crucial factor for the effective persuasion of public opinion and the promotion of a flagship species (Bowen-Jones and Entwistle 2002). C&R anglers identified themselves with the golden mahseer based on their recreational experiences and several mentioned the importance of revenue generated through angling tourism. Village members identified themselves with golden mahseer because of its value as a food source and from traditional stories of the fish's prowess and elusiveness. Although most village members supported golden mahseer as a potential flagship species, some believed that more than one species should be promoted to encourage wider benefits to their rivers.

Respondents were then asked about unique features that would help make either the rosy barb or golden mahseer good flagship species. The forest officials associated phrases such as large size, extremely sought after, golden, beautiful and local pride with the golden mahseer. However, some forest officials described the larger rosy barb individuals as more beautiful than the golden mahseer. The C&R anglers on the other hand preferred the golden mahseer, and used adjectives such as elusive, clever, perceptive, beautiful, fighter and intelligent to describe the species. The village members mentioned that the golden mahseer had brought positive recognition to the area because it attracted international C&R anglers to the region (Table 2).

Both the forest officials and C&R anglers highlighted that the golden mahseer was a revenue generator as part of C&R angling tourism in the region, and had brought economic benefits to some local people. The villagers also mentioned that C&R angling opportunities had generated revenue for communities in the area, and had helped promote a positive association with this species. However, 11 per cent of the C&R anglers and 21 per cent of the village members mentioned that more financial transparency was required if angling were to continue to be seen as a local benefit (e.g. how money was distributed among participants).

Forest managers recognised habitat destruction through illegal sand and boulder mining as a major threat to fish. These officials frequently mentioned that village members' support is crucial to prevent these activities, because regular patrolling of vast stretches of riverbeds was an unmanageable task given the current work force. However, some forest managers also suggested that illegal fishing practices were the main problem in the area. The C&R anglers suggested that for golden mahseer to survive in the wild, more conservation awareness and targeted

Table 2 Summary of stakeholders' dominant responses to assess the rosy barb and golden mahseer as flagship species

	Stakeholders' association (rosy barb)			Stakeholders' association (golden mahseer)		
Criteria	Forest officials (n = 21)	C&R anglers (n = 18)	Village members (n = 140)	Forest officials (n = 21)	C&R anglers (n = 18)	Village members (n = 140)
Traditional and cultural association	Aquarium species	Not important from a C&R angling perspective	Revenue generator (aquarium trade). Seldom seen (disadvantage)	Pride of the area	Revenue generator (C&R angling)	Food source. Frequently seen in the wild
Unique features	Large individuals more beautiful than golden mahseer	Beautiful. However, no comparison to the mighty mahseer	Not very visible (small in size)	Large size, extremely sought after, golden, beautiful, local pride	Elusive, clever, perceptive, beautiful, fighter, intelligent	Brings positive recognition to the region – attracts international C&R anglers
Social and economic benefits	Some local revenue generation (aquarium trade)	None from a C&R angling perspective	Very little, in comparison to golden mahseer through C&R angling	Revenue generator for some local stakeholders	Economic benefits to local communities (C&R angling)	Job opportunities and economic incentives (C&R angling)
Further suggestions	Illegal sand and boulder mining damaging habitat	More conservation awareness required	More patrolling by forest officials; harsher punishments for offenders	Destructive fishing practices threatening fish species. Support from village communities crucial	More transparency needed during C&R angling profit sharing. Targeted conservation policies need to be implemented	More transparency needed during C&R angling profit sharing. More community involvement

C&R: catch and release

Area 2014 doi: 10.1111/area.12124

policies need to be implemented and these should take into account the needs and concerns of local stakeholders. Most village members felt that their participation for conservation initiatives was not fully tapped into and they were seldom approached by the agencies concerned. Other village members wanted preventive measures such as patrols and harsher punishments for offenders (see Table 2).

An assessment was then carried out to assess the suitability of rosy barb and golden mahseer as possible flagship species (Bowen-Jones and Entwistle 2002; Farjon *et al*. 2004). Although the rosy barb was localised in a few river stretches and locally recognised because of the aquarium trade, the golden mahseer had a wide distribution and was internationally renowned as a game fish. Both of these species had charismatic body colour, which would help promote their role as a flagship species. However, the presence of strong cultural and positive associations with the golden mahseer, associated with international angling tourism, brought a sense of local pride among the stakeholders. This was expressed most frequently and strongly among village members. C&R angling tourism in the region was also the main factor cited for golden mahseer selection over the rosy barb. Further, among the village members, golden mahseer provided food and monetary benefits through tourism. All stakeholders suggested that if more strategies were in place for golden mahseer protection there would be tangible social and economic benefits, which would further support conservation efforts for local rivers (Table 3). From our qualitative assessment of interview responses, the golden mahseer was strongly preferred as a flagship species among all local stakeholder groups.

Discussion

Golden mahseer (*Tor putitora*) is endemic to India and found in Himalayan rivers (Nautiyal 1984; Nautiyal *et al*. 2008). Its native name, mahseer ('maha seer'), refers to its large head or it being the 'great tiger' of the river (Sharma 2003). Fishermen and C&R anglers alike passionately describe this fish as being elusive, colourful, beautiful, elegant and aristocratic (Nautiyal 1985). Golden mahseer is an international sought-after game fish and a regional table delicacy (Nautiyal 1984; Bhatt *et al*. 2004; Islam and Tanaka 2006; Patiyal *et al*. 2010). Adult fish can exceed three metres in length, making it one of the largest freshwater fishes in India (Bhatt *et al*. 2000 2004). Sadly, the IUCN (2012) has categorised golden mahseer as endangered. Of the range of environmental factors that have continued to contribute to declining population size of this fish, indiscriminate poaching (sometimes by the illegal use of poisons and dynamite) are of critical concern (Atkore *et al*. 2011; Akhtar *et al*. 2013).

Indian rivers where golden mahseer are found continue to suffer from various anthropogenic stressors, and a flagship species approach supported by a range of stakeholders could act as a river conservation strategy. The national and international reputation of the golden mahseer, promoted mainly through C&R anglers, brings with it a sense of local pride. Further, the economic opportunities for local communities through C&R angling tourism makes the golden mahseer the species of choice among the stakeholder groups we interviewed (see Table 3). Importantly, mahseer species have been described as having key ecological roles within rivers (Everard and Kataria 2011), which ensure that their protection leads to a range of ecological benefits.

Table 3 Summary of assessment of rosy barb and golden mahseer as flagship species (predominant response) following Bowen-Jones and Entwistle (2002) and Farjon *et al*. (2004)

Criteria	Rosy barb	Golden mahseer
Geographical distribution	Localised in few river stretches	Widespread distribution
Conservation status	Threatened	Threatened
Ecological role	Forms part of the food web	Local apex species
Recognition	Locally recognised	Internationally renowned
Existing usage	Not a symbol of any organisation	Not a symbol of any organisation
Charisma	Small size, beautiful red colour	Impressive large size and golden colour
Cultural significance	None	Present
Positive associations	None	Local pride – area frequented by international anglers
Local knowledge	Local people aware of species	Well known locally
Local names	None	Local name = common name: golden mahseer
Scientific value	Low	High
Utility	Sometimes as aquarium species	Food source; economic benefits through C&R angling

C&R: catch and release

The successful implementation of the golden mahseer as a flagship species will have to involve a range of key stakeholders. For example, forest officials are needed to advise on current environmental rules and conservation strategies, particularly relating to the ecological value of these potential flagship fish. Further, local forest officials will be the enforcers of rules that regulate flagship species protection. Therefore, it is paramount that this group communicates openly with all stakeholders. C&R anglers interested in safeguarding the golden mahseer (and other game fish) from harmful stressors are important for promoting the flagship species concept and supporting the monitoring of fish population status and overall river health. Preserving C&R angling opportunities presents a strong incentive for these stakeholders to become actively involved in conservation, and provides strong positive feedback for this conservation approach. It is important to emphasise that angling provides essential monitoring and visual reassurance that flagship species are thriving in their protected habitats. Unlike tigers or elephants, confirmation of fish presence requires more than a safari vacation.

Local village members bridge the roles of forest official and C&R anglers. To ensure the continued protection of a flagship fish, damaging activities like sand and boulder mining and illegal fishing techniques need to stop. Securing economic incentives associated with C&R angling could encourage the cessation of these illegal activities and promote the conservation of rivers, while at the same time improving villagers' livelihoods (Everard and Kataria 2011).

Our interviews pointed to the golden mahseer as the best choice for a flagship species – and this was directly linked to C&R angling. The rosy barb did not provide any monetary benefits, as it was not a target species for C&R angling, therefore not given priority over the golden mahseer. The inclination of the village members towards the golden mahseer in comparison to the rosy barb was due to traditional attachment (i.e. as a food source) and importantly because of the perceived incentives through C&R angling. The potential monetary gain from C&R angling for village members was generally associated with involvement in these activities in the recent past (i.e. individuals had made money as guides). However, dissatisfaction with the distribution of money and the desire for more transparency in profit sharing is a major hurdle towards successful implementation of both flagship status and sustainable golden mahseer angling within the study region. C&R anglers and the money that they would bring in to the region would be the main drivers for the successful implementation of conservation programmes linked to golden mahseer. Everard and Kataria (2011) highlight these issues and suggest more profit sharing with local communities to create a sustainable relationship among all interested groups. C&R tour operators should ensure that local communities are not marginalised if they wish to foster more local-scale support for their industry.

Despite a preference among the stakeholders for the golden mahseer as a flagship species, there were conflicts of opinion. Eleven per cent of the village respondents mentioned that the central government should be involved in the protection of river quality. When discussed further, several individuals had approached the local government departments to raise their concerns about problems in their local rivers. Having not seen any conservation strategy undertaken over the years, most of these participants expressed bitter attitudes towards these regulators. This situation highlights the need for conservation involving local stakeholders as key players. The perceived lack of action by regulators erodes overall confidence in conservation policies and weakens the potential utility of a flagship species (Holl 1996; Metcalfe 2003). However, to an extent, in this region tigers have been a successful model of the flagship concept for over 40 years (Johnsingh and Joshua 1994; Post and Pandav 2013). This clearly supports the notion that a charismatic species helps to focus regulators' actions.

Rather than one flagship species, some respondents pointed out that conservation should encompass all fish species present in the rivers. These respondents were typically more interested in a holistic approach to river ecosystem conservation because in their opinion rivers were more variable than forests (e.g. perceived fluctuations in river levels vs static forest). Although this is an interesting observation, it highlights how education about ecosystem ecology needs to be embedded into flagship species conservation campaigns (Bowen-Jones and Entwistle 2002; Walpole and Leader-Williams 2002).

The golden mahseer as a flagship species for Himalayan rivers demonstrates promise, given its widespread recognition in the C&R angling world and its current IUCN status (IUCN 2012). The socioeconomic and political profile of Indian Himalayan States is different from the rest of India. People in the Himalayan region are known to live in harmony with nature and largely practice sustainable use of natural resources as part of their livelihoods. Therefore, the proposed conservation programme using the golden mahseer as a flagship species has clear potential. Already, talks are underway to start a mahseer conservation programme in collaboration with the Wildlife Institute of India, Dehradun, with participation of local communities and other stakeholders (N. Gupta personal communication with K. Sivakumar). However, along with embracing the golden mahseer as a flagship species, it should also be listed in India's Wildlife Protection Act, because this would provide the required legislative support. Nevertheless, controlled and monitored C&R angling has to continue in the region for the long-term

survival of the golden mahseer so that it can serve its role as a flagship conservation species. The economic benefits associated with this species play a significant role in local stakeholders' support for this species and provide tangible, positive feedback for local conservation. Importantly, the effectiveness of the golden mahseer as a flagship species needs to be tested periodically (Root-Bernstein and Armesto 2013), because opinions of local stakeholders vary over time (Barua *et al*. 2011) and loss of financial incentives would likely result in resumed sand and gravel dredging or even poaching of precious game fish.

Acknowledgements

We thank the Director, Wildlife Institute of India and the Chief Wildlife Warden, Uttarakhand for permission to undertake this study. We thank Directors and DFOs of Corbett and Rajaji National Parks. Mr Sumantha Ghosh and Vinod Belwal aided during fieldwork. Navneet Singh and Dr Robert Francis assisted this work. This study was funded by King's College London.

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Chapter 8

Conclusion

The current research focused on the Indian Himalayan Rivers in the state of Uttarakhand and investigated novel strategies for their protection and long-term conservation. Since this interdisciplinary study was first of its kind for this region, it could potentially assist in generating baseline information for the threatened river ecosystems here, and greatly help inform conservation plans for river ecosystems. The information gathered through multiple field surveys and presented in the previous chapters could potentially improve the knowledge gap regarding the current status of rivers and their fish species in India. The results obtained from this study will be transferred to organizations in India, (i.e. the Ministry of Environment and Forests (MoEF), State Department of Forests and Wildlife, WWF-India), as well as various local and regional non-governmental organizations working to safeguard not just the Himalayan Rivers, but rivers across India. This could further assist in generating legislative support, financial assistance and conservation projects targeting these rivers. Additionally, the findings could be utilized to initiate education and awareness campaigns among local and regional stakeholders to ensure a better future for the river ecosystems in this region and in India.

The terrestrial protected areas (tPAs) and managed reaches, (i.e. temple pools and angling pools) of the region were studied to understand if they provided any direct or indirect protection to the river reaches and fish

species. Although the studied tPAs were not exclusively set up to protect freshwater ecosystems, they did provide some protection to river and stream reaches within their legislatively defined boundaries. However, this protection was solely unintentional which was evident from the temporary damming of streams within Rajaji tiger reserve every summer to provide drinking water for park animals. This could be because of lack of awareness among forest managers. The protection provided by these tPAs was mainly because of the legislative control over people (local community members, and tourists for tiger and elephant tourism) entering the park, which greatly reduced the anthropogenic threats to river and stream reaches within these tPAs.

There is a growing debate in India over the setting up of new, legislatively defined areas to protect river ecosystems and exclude the presence of humans as much as possible. Previous studies conducted by Abraham and Kelkar, 2012 in five protected areas of the Western Ghats of India; and by Sarker et al., 2013 on the river Gerua both within and outside Katerniaghat Wildlife Sanctuary (Uttar Pradesh, India) have highlighted the potential benefits of current tPAs for freshwater reaches within their defined boundaries. The authors mention that total fish species richness was significantly higher inside protected areas than unprotected areas due to reduced anthropogenic threats within protected areas. Similar results were obtained during this study therefore; the indirect protection provided to freshwater ecosystems by the studied tPAs cannot be completely dismissed. Nonetheless, simply setting up new protected areas (and excluding human presence) to protect river ecosystems is not what this study advocates, as there is an urgent need to examine the remaining existing tPAs (with river

reaches within their boundaries) in India before suggesting such an approach.

The river reaches within temple pools (situated on the Kosi, Ramganga and Khoh Rivers) had higher fish species richness compared to reaches outside their boundaries, and did provide some protection to the region's freshwater fish species. Similar observations have been recorded by Dandekar, 2011 from other temple pools in India, and by Everard and Kataria, 2011 from the Ramganga River. Nonetheless, discussions with temple priests at these pools have revealed the weakening religious understanding among village youths and diminishing traditional teachings from village elders. Fishing for species which had been long protected through religious beliefs and taboos has increased at temple pools. The use of explosives to catch fish species had been observed at the studied temple pools.

The angling pools situated on the Kosi and Ramganga Rivers too had higher fish species richness in comparison to unprotected reaches. However, the protection provided to these river reaches by local angling associations primarily concentrated on key angling fish species such as the mahseer. This is because of the socio-economic benefits associated with this species. Any protection to other fish species in the similar habitat was indirect and due to the protection of the mahseer, described previously as an iconic species by Everard and Kataria, 2011. It was very interesting to note that the socio-economic opportunities associated with a fish species had local stakeholder support for the protection of river ecosystem. Similar findings have been reported from the Western Ghats of India by Pinder and Raghavan, 2013.

However, the growing concerns among some local stakeholders regarding the effects of recreational angling on target fish species; and issues with sharing of angling profit with local village communities is a hindrance not just for the recreational angling industry in the region, but also for the long-term protection of river ecosystems.

During the course of the field surveys, informal discussions with village communities, and semi-structured interviews, it was noted that local community support for river conservation, although widely present, was seldom utilized by the previous and ongoing conservation policies. There was a need to highlight this support and potential benefits of involving local communities in future river conservation programs to the policy makers (state and central level). However, it was first essential to examine communities which worked together with conservation policies in protecting and conserving river reaches within their jurisdiction in India. An opportunity was available to study the river conservation work being carried out by the residents of Kanalsi village in the neighbouring state of Haryana, north India (27°39' to 30°35' N, 74°28' to 77°36' E). This opportunity was taken up in the month of December 2012 as no such community conservation initiative at this scale was available in the study area; and this additional study from a different biogeographic region of India, (i.e. semi-arid) could potentially assist in providing a more holistic report to policy makers (see published article below).

Journal of Development Management (ISSN 2321-0761)
Volume 1, No. 3
July-September, 2013

Reflections on a Successful Community Conservation Programme in Haryana, India

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Abstract

In India, conservation of river ecosystems and its associated biodiversity is essential due to a growing human population and increased water demand. Conservation efforts at local scale may protect individual species from anthropogenic stressors and protect biodiversity. The present study is based on a community conservation programme in north India to protect river ecosystem and its surrounding faunal species. During December 2012, twenty two sites across the Thapana and Somb Rivers were sampled for in-river habitat characteristics and faunal species. In total, 12 fish, 5 mammalian, 2 reptilian, 5 odonate, 7 lepidopteran, and 79 avian species were recorded. Within community conserved sites, we found lower levels of riverine degradation and higher faunal diversity. Impacts to water quality, clearing of riparian vegetation and sand and boulder mining were the likely cause for degradation of riverine habitats and the loss of faunal species outside community conserved sites. This article highlights the importance of community conservation initiatives for the conservation of river ecosystems and associated biodiversity.

Acronyms/Abbreviations

CCP: Community conservation programme, CCS: Community conserved sites, FPAs: Fresh Water Protected Areas, NMM: Nadi Mitra Mandal

Introduction

India has a rich network of river systems flowing across its different biogeographic zones.[1] Unfortunately, with a rapidly growing population, a growth in urbanization and an increase in water demand, the country is witnessing wide-scale overexploitation of river ecosystems through water pollution, flow modification, destruction and degradation of habitats and stocking of exotic species to support the region's protein requirements.[2-4] Despite these threats, rivers' ecosystems here have not been able to muster the support as much as terrestrial habitats,[5] even with the presence of powerful legislations such as the Indian Water (Prevention and Control of Pollution) Act, 1974, the Water (Prevention and Control of Pollution) Cess Act, 1977 and the Environment (Protection) Act, 1986. In addition, no freshwater fish species are listed in the Schedules of Protected Species in the Wildlife (Protection) Act, 1972.[6]

Various river conservation approaches have been utilized and proposed across India, but with mixed results. River conservation policies have often not obtained the

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desired results, due to the ever-increasing demand for river resources and a top-down management practice.[7,8] Suggestion of setting up of Freshwater Protected Areas (FPAs) could provide the desired protection and possible social and economic benefits for local communities,[9-15] but are yet to be implemented. Finally the support from recreational angling communities.[16] as an angler's experience depends on the survival of their pursued fishes,[17] is still in its early stages. In view of the above threats, there is an urgent need to investigate other potential strategies. Engaging local communities through awareness of social and economic returns, cultural associations or religious beliefs[18] can produce the desired support and act as a supplementary conservation tool for rivers across India.[19-23]

In view of the above suggestion, the river and biodiversity conservation initiatives started by the villagers of Kanalsi in the north Indian State of Haryana was the focus of attention. Emphasis was placed on the rivers Thapana and Somb flowing near this village to investigate the community's conservation initiatives. The in-river habitat characteristics along with the avian, mammalian, reptilian, odonate, lepidopteran, and fish species associated with these rivers were recorded during December 2012. The objectives of this article are to (a) investigate the benefits of community conservation initiatives for the rivers and associated biodiversity; (b) record the presence of faunal species within/outside community conserved sites; and (c) identify and suggest possible preventive measures for any stressors causing disturbances within/outside such protected sites.

Background of the study area

Kanalsi is an agricultural village, near the city of Jagadhri in Yamuna Nagar district, located in the north Indian State of Haryana (27°39' to 30°35' N; 74°28' to 77°36'E). The area is renowned for stainless steel production and timber trading. The crops grown by the farmers here are sugarcane (Saccharum) and poplar trees (Populus). The river Somb meets river Yamuna downstream near Kanalsi village (Figure I). The river Thapana meets river Somb at Kanalsi and is in turn formed by the convergence of two tributaries: Thapana I and Thapana II. For this survey, rivers Somb and Thapana were divided into four sampling stations, i.e., (1) Somb River; (2) Thapana (Thapana I and Thapana II); (3) Thapana I; and (4) Thapana II. Within these four sampling stations and depending on accessibility, further 22 sampling sites were set up, i.e., (a) on river Somb, seven sampling sites (S_1 - S_7) were present: S_1 (meeting point of river Yamuna and Somb), S_2 (opposite Kanalsi village), S_3 (Fatehgarh), S_4 (upstream of Maher Majra), S_5 (Maher Majra), S_6 (purana ghat, Kanalsi) and S_7 (confluence of Somb and Thapana rivers); (b) sampling sites S_8 - S_{12} were present on river Thapana (Thapana I and Thapana II): S_8 (before Thapana meets river Somb), S_9 (near Mandoli), S_{10} (bridge-1, Mandoli), S_{11} (Mandoli-Thapana) and S_{12} (Dhampura); (c) sampling sites S_{13} - S_{18} were located on Thapana I: S_{13} (Gaajdinpur), S_{14} (Nawazpur), S_{15} (Haldhari, Nawazpur), S_{16} (Lakkad bridge), S_{17} (Lakkad) and S_{18} (Bhilpura); and (d) sampling sites S_{19} - S_{22} were located on Thapana II: S_{19} (Bichpari), S_{20} (Rampur), S_{21} (Haldari) and S_{22} (Jai Rampur Ghat).

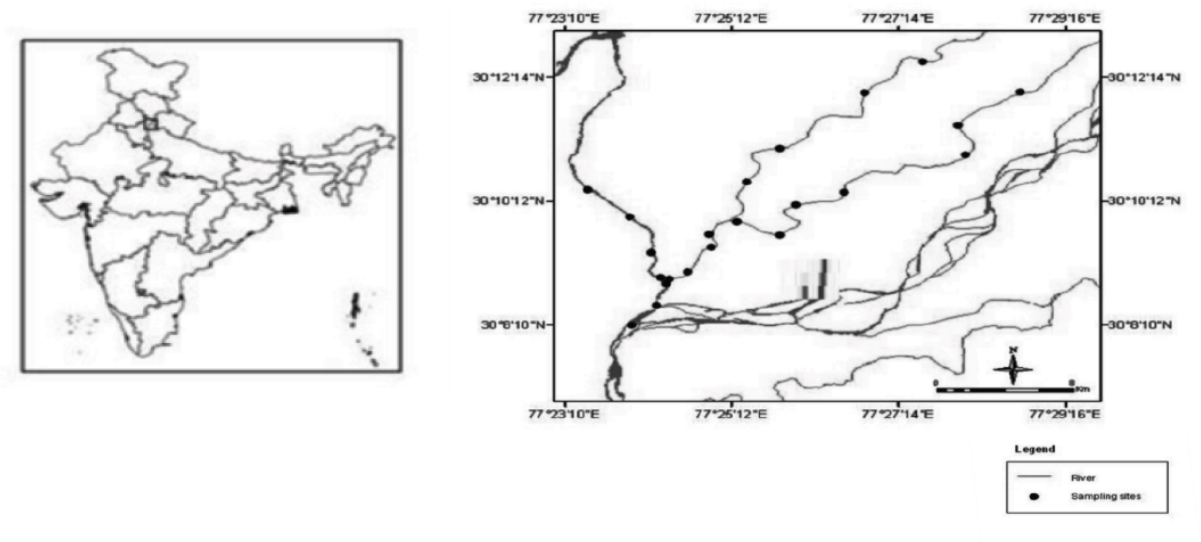

Figure 1: Map of the studied area

The coverage of the riparian zone, its canopy over the water surface and aquatic vegetation were recorded visually. Sampling occurred during a winter month (December) throughout the day (9am to 5pm). Fisher were sampled at each site using cast nets (mesh size: 4cm x 4cm; 3cm x 3cm), mosquito nets (mesh size 0.2cm x 0.2cm) and bait fishing using a fishing rod. Same efforts were used at all sites. Fishes caught were identified at the species level with the help of keys prescribed by Talwar & Jhingran (1991) and Jayaram (1999). The avian, mammalian, reptilian, odonate and lepidopteran species were assessed by photographing and recording individual species both during rest and in flight, using a Canon Power Shot SX210 IS 14.1MP, 14X optical zoom digital camera. All specimens were identified based on the latest publications by Subramanian (2005), Bombay Natural History Society (2008) and Grimmett et al. (2012). Both natural and anthropogenic threats were recorded at each sampling site.

Community Conservation Programme

The river and biodiversity conservation initiatives were started by the local members of the Nadi Mitra Mandal (NMM), Kanalsi grid, and encompassed stretches of the Thapana River. This initiative was overseen by PEACE Institute Charitable Trust, New Delhi in association with Thames Rivers Trust, United Kingdom. The aim was "to educate and involve the local communities based along the river to monitor and protect the river stretches; and develop new strategies which could be promoted to similar communities across the nation". Despite being based in an agricultural region, the people of Kanalsi have always been aware of the rich biodiversity of their area. *"You will not spot so many species of birds in just one day, anywhere in India"*, replied a proud respondent before the survey. *"We don't bother the animals; they don't bother us; and we both get on with our business"*, explained another respondent.

In total, 12 fish species were caught during the sampling period, 11 belonging to the family Cyprinidae and 1 to Belonidae. There were 5 mammalian species noted (5 families; 4 orders); with Nilgai *(Boselaphus tragocamelus)* being the most abundant

species recorded. Two reptilian species (2 families; 1 order) were documented. Five lepidopteran species (1 family; 1 order); and 7 odonate species (2 families; 1 order) were recorded. Seventy-nine avian species were noted down from the sampling sites. Of the avian species, River Lapwing *(Vanellus duvaucelii)*, a common resident, was near threatened; forty-nine species were common or locally common residents and 15 species were common or not common winter visitors.

Positive conservation approaches were visible around the community conserved sites, i.e., saplings of native trees could be spotted on the banks of the Thapana River. *"They will increase the forest cover one day for our grandchildren and will make the banks more stable"*, replied one respondent. Interestingly, a large portion of the Panchayat land near Thapana River was set aside from cultivation giving rise to a dense growth of scrubs and grasses. *"We are trying our best to keep this portion free of agriculture for the native birds"*, stated one respondent. This initiative was successful, as nesting sites of many endemic and migratory birds were spotted here. A 5 km stretch on the Thapana River near Kanalsi village was found to be rich in faunal species and one of the reasons was that the villagers at this site practiced organic farming and avoided dumping household wastes directly into the river. They also ensured that they did not farm close to the river banks. This had given rise to lush riparian growth of scrub and grasses here, which attracted winter migratory birds in large numbers and provided nesting habitats for local species. *"It is our mini-wetland"* remarked one respondent.

One of the necessary steps for a community conservation initiative to gather momentum and spread to nearby villages is mass awareness and the people of Kanalsi had ensured that this was the case. Visible sign boards were erected by the villagers clearly stating that the Thapana River was protected by the NMM members and requesting the locals not to fish and pollute the river. Throughout our sampling period on the Thapana and Somb Rivers, we were questioned about our work by passing-by villagers and were warned not to damage the rivers and the local biodiversity in any way due to our sampling techniques. *"Doesn't your cast net injure the fish during your sampling"*, inquired one villager. *"I hope you are not capturing the birds simply to take a photograph"*, warned another.

In comparison, stretches of Thapana and Somb Rivers outside the community conservation area suffered from various anthropogenic stressors. Local people from nearby villages were spotted using illegal fishing techniques on the Somb River. On both these rivers, there was clearing of riparian vegetation along the banks to make way for agricultural land sand and boulder mining was prevalent and negligible faunal species were recorded. Outside community conservation sites, there were presence of sugarcane and turmeric (Curcuma longa) fields close to the banks of these two rivers and large amounts of urea and other chemicals were being used on the crops. At one site, the agricultural fields had a system of parallel cuts to allow the drainage of excess water into the Somb River. This was particularly concerning as the crop chemicals could be transported into the river and be a possible reason for the choking of river stretches with aquatic vegetation. When asked about the damaging effects these

chemicals could have if they entered the river water, one of the villager responded, *"We just don't have the time to indulge in organic farming. The land is less fertile now and the output is less through organic farming"*. Various sources of pollution were also observed at non-conserved sites, i.e., dumping of dry waste material directly into the river; oil pollution from the washing of tractors and motorcycles; temporary bullock-carts crossing through river stretches; and frequent religious immersions. At another site, Thapana I River had been channelized by the villagers for irrigation purposes.

Conclusion

Both Somb and Thapana river systems support a large number of faunal species. The avian population across the sampling sites are in a very healthy condition as many nesting sites were observed during the survey. The river and biodiversity conservation programme started by the villagers of Kanalsi has been very successful, gained momentum and voluntarily recruited many interested individuals. Despite these benefits, both Thapana and Somb Rivers outside the community conserved sites are facing threats due to rapid urbanization and the ever-increasing demand from the agriculture sector to feed an increasing population. For the long term survival of these precious rivers and their faunal species outside community conserved areas, the following steps should be undertaken by villages based alongside these rivers: (a) mass awareness programme should be undertaken to educate village members about the benefits of rivers and the long-term effects of damaging such a vital ecosystem; (b) native trees should be grown along the Thapana and Somb Rivers for the stabilization of their banks and to provide habitats for local faunal species; (c)the removal of riparian vegetation and clearing of scrubs and grasses to make way for new agricultural land should be minimized; (d)indiscriminate use of chemicals in agricultural practices should be controlled; and (e) planting of poplar, sugarcane and turmeric plants should occur as further away from the river banks as possible.

For its effective implementation and success, future conservation plans should take into account community involvement based on trust, transparency and accountability[24,25] and address the local people in order to utilize their full cooperation.[26] Community level conservation of rivers and its associated biodiversity, like the one mentioned above, has been able to achieve the desired results because the plans were centred around the needs and concerns of the people of Kanalsi.[27] The time has come to recognize the importance of local participation for protecting and conserving river ecosystems in India.

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The angling review provides information on the status of recreational fisheries in India. Although such reviews are common in developed countries such as the United States and Canada, this is the first review of its kind for India, and hopefully would offer crucial information for policy makers in the near future. With the expanding recreational angling sector in India, especially in key biodiversity hotspots, there is a growing concern regarding this activity's management and potential benefits/negative effects on freshwater ecosystems (see Pinder and Raghavan, 2013). This review has attempted to address some of these concerns, and recommends that further research is urgently needed before setting up any angling guidelines or angling directed policies in India.

The responses obtained from the anglers fishing in India are indeed promising, (i.e. significant level of conservation awareness; willingness to support future conservation and management initiatives related to recreational fishing) however, care needs to be taken to ensure transparency and satisfaction is maintained regarding socio-economic benefits among all involved stakeholders. The global catch-and-release angling survey which targeted international and domestic anglers fishing in Indian rivers (first of its kind for India) too highlights their conservation awareness and willingness to cooperate with future conservation policies. The earlier assumption within various government organizations in the Himalayas and the rest of India was that catch-and-release angling was solely about the fish caught by international visitors and revenue earned (in dollars) by the angling associations. Further, Everard and Kataria, 2011, and the anglers themselves have expressed concerns over the satisfactory distribution of

angling revenue among all involved stakeholders. However, this survey attempted to broaden this understanding and suggest measures to be taken by operating angling associations in the Himalayan region and elsewhere in India. The semi-structured interviews with local stakeholders led to the suggestion of setting up of community conservation units (CCUs) within local villages, the members of whom could interact with local angling associations and ensure that appropriate dividends reach their communities. Such novel strategies have the potential to address the needs and concerns of local communities, and utilize their full cooperation for the protection of angling target fish species and their habitat. The analysis of anglers' logbook data and semi-structured interviews revealed that angling generated local support through capacity building and sustainable development. More importantly, this rapidly growing leisure activity had the potential to provide catch statistics to scientists, assist government and non-governmental organisations with environmental monitoring, and overall assist with conservation of rivers and fish species in India.

With the increasing threats to river ecosystems not just in the Himalayan region but in India, the currently applied conservation strategies for their protection are over-stretched. Novel strategies to protect river reaches at local, regional and national scale are urgently required. Recreational fishers as a stakeholder group across India could assist with ongoing and future river conservation policies. The support of local communities towards this activity due to economic benefits associated with recreational angling is advantageous and could be further applied for various conservation approaches. However, to fully explore this potential, collaboration among

local communities, recreational fishers and government agencies needs to be addressed appropriately for a satisfactory outcome.

One of the interesting aspects of this research was the frequent mention of the golden mahseer, an endemic fish species of the Himalayan Rivers. From interacting with forest managers regarding permission letters and forest accommodation, to passing-by local village members near the sampling sites, the golden mahseer always came up as a topic of discussion. One only had to speak about angling in the Himalayas to a recreational fisher (international or domestic) and the golden mahseer would be mentioned immediately. Moreover, everyone spoken to had something to say about this species. More interestingly however, the mahseer species were one of the fish species which I was urged to locate during the numerous field surveys on the Thapana and Somb rivers in Haryana. When enquired, the villagers informed me that the presence of the mahseer would ensure an angling tourism in the region just like the other regions of India.

With this background and the field surveys, (i.e. fish sampling, semi-structured interviews) in the Himalayan region, an attempt was made to understand the availability and applicability of a freshwater fish species as a flagship conservation species – a novel strategy for India. After all, the Indian Himalayan region proudly boasted of its terrestrial flagship species, (e.g. tigers and elephants). The associated conservation and financial backings for these terrestrial species was tremendous, and had to a certain extent assisted with their protection. The subsequent investigation revealed the golden mahseer as a suitable flagship conservation species for Himalayan

Rivers. This was due to its widespread recognition in the catch-and-release angling world and its current IUCN status, (i.e. Endangered; IUCN, 2014). The economic benefits associated with this species played a significant role in local stakeholders' support for this species.

Amidst the time availability of a PhD degree and limited financial resources, the current research examined approaches such as tPAs, managed reaches, (i.e. temple pools, angling pools), community-conservation initiatives, views and opinions of recreational anglers, catch-and-release angling as a monitoring tool, and the designation of a freshwater fish as a flagship conservation species for the protection and long-term conservation of the Himalayan rivers. One of the long-term goals of this research was to inform policy makers at the state and central level regarding the availability and applicability of novel approaches for benefitting the rivers in India. However, such a proposal would need to amalgamate the studied approaches, and the lessons learnt during the course of this research. In this regard and to begin with, a general article suggesting yet another novel idea, yet encompassing the above research was felt appropriate to inform policy makers in India. The journal chosen for this article was *Current Science*, a leading interdisciplinary science journal in India, which was published in collaboration with the Indian Academy of Sciences and read by students, researchers, scientists and policy makers alike. With the current threats facing the Himalayan Rivers, this article (first in a series of articles) was presented to the larger Indian scientific community and policy makers with a sincere hope that some of the findings of this research would be considered, and potentially applied to bring

about protection and long-term conservation of the threatened rivers of India (see published article below).

Freshwater fish safe zones: a prospective conservation strategy for river ecosystems in India

Nishikant Gupta, Rajeev Raghavan, K. Sivakumar and Vinod B. Mathur

The 21st century is a 'time of crisis' for freshwater ecosystems and their resources[1]. A multitude of stressors, including urbanization and associated habitat alteration and loss, alien invasive species, overharvest, pollution and climate change, have resulted in freshwater ecosystems and freshwater fish becoming one of the most threatened ecosystems and taxa on Earth[2–8]. However, the lack of connection between freshwater biodiversity and the general public[9] has resulted in less attention being focused on freshwater-related conservation issues.

The Convention on Biological Diversity's Aichi Strategic Plan for Biodiversity 2011–2020 has set out a series of biodiversity targets where protection and conservation of rivers and their biodiversity is an important priority[10]. The plan recommends that by the year 2020, 'at least 17% of terrestrial and inland water is conserved through effectively and equitably managed, ecologically representative and well-connected systems of Protected Areas (PAs), and other effective area-based conservation measures[10].' Further, it also recommends that 'all fish are managed and harvested sustainably, legally and applying ecosystem-based approaches, so that overfishing is avoided[10].'

India, a megadiversity nation, has over 600 PAs covering about 5% of its total land area[11]. Of this, only a small fraction has been set up to protect freshwater fauna, largely focused on charismatic taxa such as Gharial (*Gavialis gangeticus*) and South Asian River Dolphin (*Platanista gangetica*). Although the freshwater ecosystems of India harbour close to 900 fish species[12] with high levels of endemism and threats[13], there are no dedicated 'formal' PAs for freshwater fish in the country.

Although some of India's major rivers flow through the boundaries of various terrestrial PAs, little or no attention is given to the health of these rivers and their biodiversity. While seasonal streams are impounded within Project Tiger Reserves during the drier summer months to provide water for the terrestrial species, various tourist roads, temporary bridges and upcoming lodges on river banks within PAs contribute to habitat degradation (N. Gupta, pers. obs.). This has been largely due to the callous attitude of policy makers in India, for whom freshwater ecosystems and fish conservation have been 'out of sight' and 'out of mind'[14].

The drastic state of Indian rivers and their biodiversity, therefore calls for novel protection and management strategies. In this context, we discuss the idea of setting up of 'freshwater fish safe zones' (FFSZs), defined as 'river reaches important for biodiversity maintenance and connectivity of a river, protected and conserved through legislative measures and local stakeholders' support' bordering the current PA network, to act as a supplementary strategy offering protection to highly threatened river reaches or fish species requiring urgent legislative intervention.

For setting up of FFSZs in India, however, the policy makers need to be convinced regarding their long-term benefits. Similar to marine ecosystems, there are multiple stakeholders associated with a riverine ecosystem[15]. Therefore, before setting up of future FFSZs, there is a need to understand resource use and dependency in the area in order to develop an integrated management plan[16]. This should also take into account the social and economic needs from a river[17]. In this context, there is a greater need for involving local stakeholders in the setting up of FFSZs.

Most PAs were initially set up to protect threatened or charismatic terrestrial species[18], and the availability of land or local stakeholders' support too played a decisive role[19]. Additionally, as far as protecting rivers and their species within PAs are concerned, the seasonal migratory behaviour of many riverine species which often encompasses multiple habitats over long distances, is a cause of concern[20–22] for the design of FFSZs. We acknowledge that the length of a river and the size of its catchment area can restrict the inclusion of its headwaters as well as its lower reaches within a PA[16]. Protecting river ecosystems also requires a catchment-scale approach[23,24] due to high permeability of freshwater ecosystems[15], as threats originating anywhere within its catchment could have profound effects on any of its reaches within FFSZs[3,22].

Nevertheless, suggestions to protect a river system's upstream catchment and downstream habitats of focal species[15,22–24] should not hinder such an approach[25], as safeguarding critical fish habitats could have wide-scale benefits in comparison to providing no defence at all[22,26]. The conservation of imperilled river ecosystems does not necessarily always have to involve the macro-scale integrated catchment management, but depending on local circumstances could also focus on the micro-scale restoration of individual habitats[15,22–24]. The protection of carefully selected reaches over an entire river can no doubt have an overall positive effect[27]. Even when FFSZs are unable to enclose an entire catchment basin, they could play a vital role by protecting spawning grounds, nurseries, refuge or migratory routes of various fish species within river reaches inside their boundaries[27]. Furthermore, PAs for marine ecosystems are a widely recognized conservation tool[16,28–30]. In addition, terrestrial ecosystems within PAs could positively benefit from protecting their bordering river ecosystems[15,30] due to the dynamic ecological and biophysical interactions between them[31].

As a first step, we provide here a list of nine important needs for planning, development and management of FFSZs in India.

(i) Every major river system should have representative FFSZs to protect critically important habitats of native and endemic fish species.

(ii) The exact geographical boundaries of river reaches that need to be managed and conserved should be well defined. River reaches having multiple jurisdiction issues, i.e. rivers shared between different states/union territories and/or river reaches managed by different state ministries, will require utmost inter and intra-governmental cooperation.

(iii) Spatial zonation of FFSZs should be delineated in the form of both 'core

area' and surrounding 'buffer areas' (similar to current terrestrial PA system in India). The buffer areas could be used to satisfy socio-economic use of local stakeholders, e.g. sustenance fishing and catch-and-release angling (spill-over effect from core area). Such an inclusive approach will help target key stakeholders, and assist in gathering their long-term support.

(iv) An integrated management plan for each FFSZ should be prepared in consultation with all relevant stakeholders, and a participatory mode of governance should be practised.

(v) The impacts of the surrounding terrestrial areas to the river reach should be evaluated, as unsustainable land management, including agricultural practices and deforestation can have devastating effect on riverine ecosystems.

(vi) The wider ecological benefits of FFSZs, including the impacts through protection provided to other freshwater-dependent species, e.g. otters, gharials and river dolphins should be assessed through rigorous field studies. Scientific research also needs to address the issue of environmental flows, as any change in the natural flow of a river can have serious consequences for habitat specialist species, many of which are usually endemic and threatened.

(vii) Keystone and flagship species connected with FFSZs need to be identified to help gather local, regional and international support for conservation and generate funds for research.

(viii) The possibility of obtaining legislative support for FFSZs should be worked out in consultation with policy makers and politicians. A detailed report applicable to the general public should also be prepared based on the scientific data obtained and one which satisfactorily argues for the setting up of FFSZs.

(ix) Regular monitoring of the established FFSZs should be carried out, and research needs to be undertaken to understand additional conservation issues.

We understand that FFSZs cannot safeguard river ecosystems from all potential threats on their own and will require the support of ongoing and future river conservation policies to have a holistic and substantial positive impact on rivers and their rich biodiversity at the landscape or basin-level. A way to deal with this issue would be to develop an approach which would first and foremost bridge the knowledge gap about the distribution and habitat ranges of threatened fish species through scientific research, and provide robust data to convince policy formulators[17]. Such an approach would not only see the amalgamation of expertise and conservation of knowledge from research scientists, but at later stages also focus on generating funds for future research activities[27].

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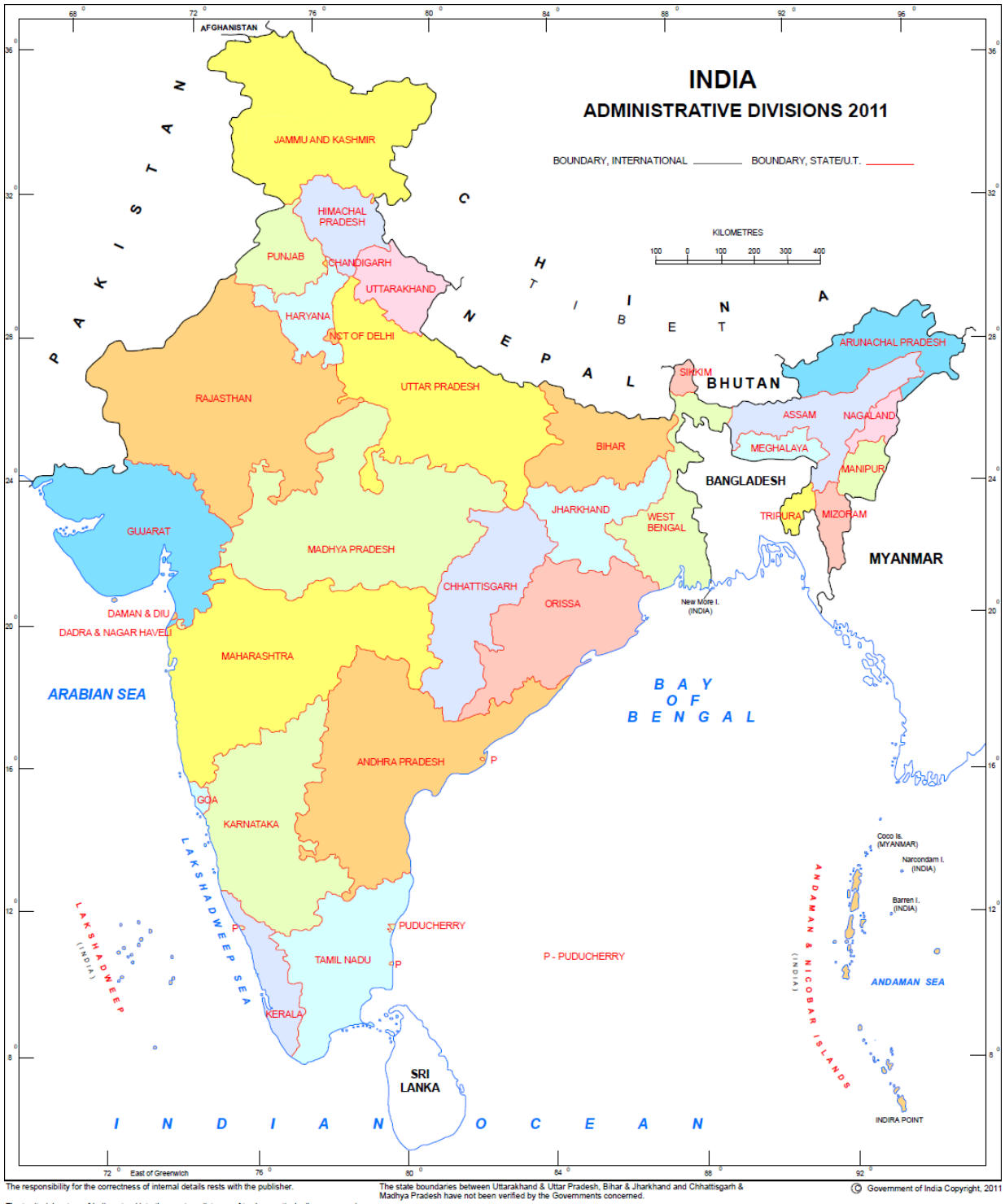
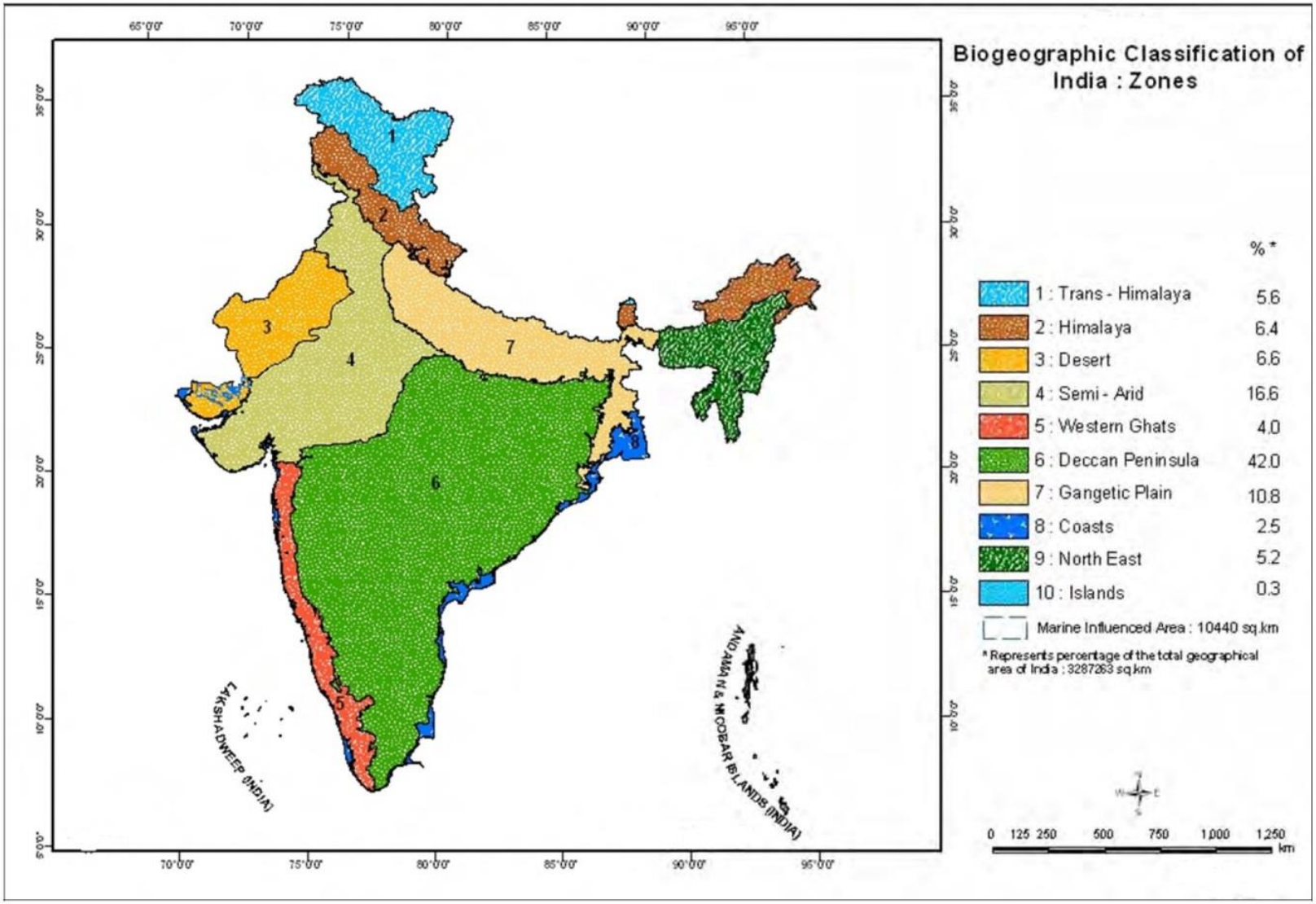
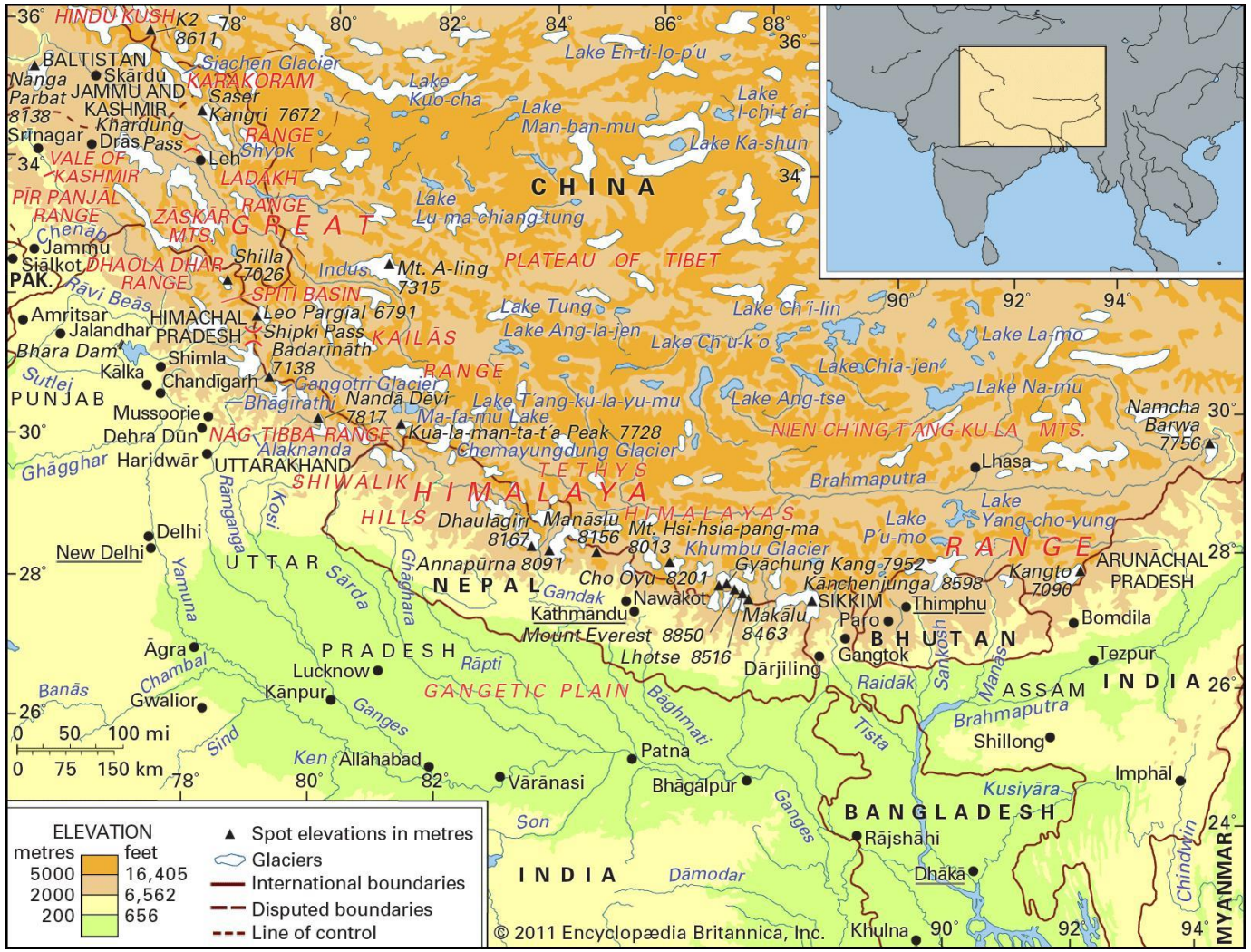
Appendix I: Administrative map of India (SOURCE: Office of the Registrar General & Census Commissioner, India, New Delhi, Ministry of Home Affairs, Government of India).



Appendix II: Biogeographic classification of India (SOURCE: Sinha et al., 2009).



Appendix III: The Indian Himalayan region. Also shown are the principal rivers. (SOURCE: Himalayas, Map, from Encyclopaedia Britannica Online, accessed March 06, 2014, http://www.britannica.com/EBchecked/media/541/The-Himalayan-mountain-ranges).



Appendix IV: Stressors impacting the Indian Himalayan region, its rivers and the fish diversity (Photo credit: N. Gupta).

Photo 1: Deforestation in the Himalayan region

Photo 2: Landslides leading to siltation of rivers

Photo 3: Sand mining on a river bed

Photo 4: Boulder mining on a river bed

Photo 5: Pollution affecting river reaches

Photo 6: Fish caught using destructive fishing techniques

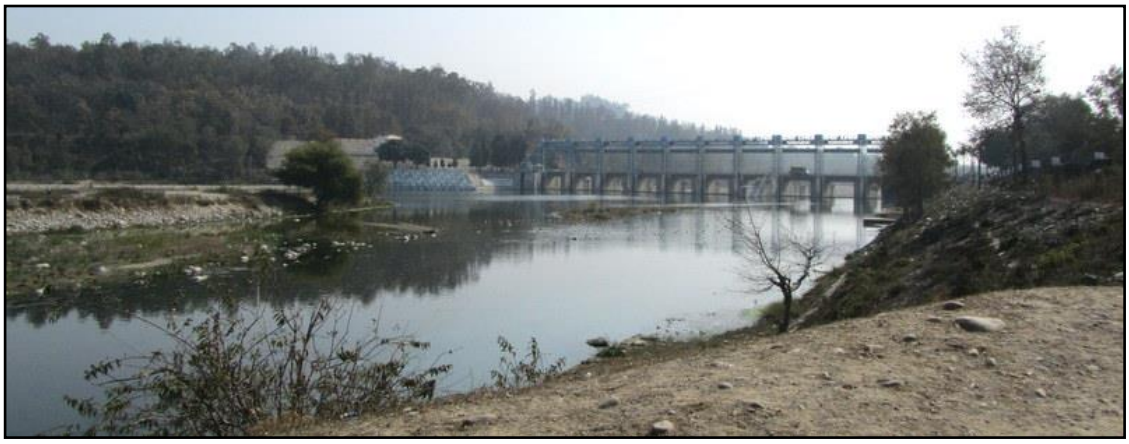
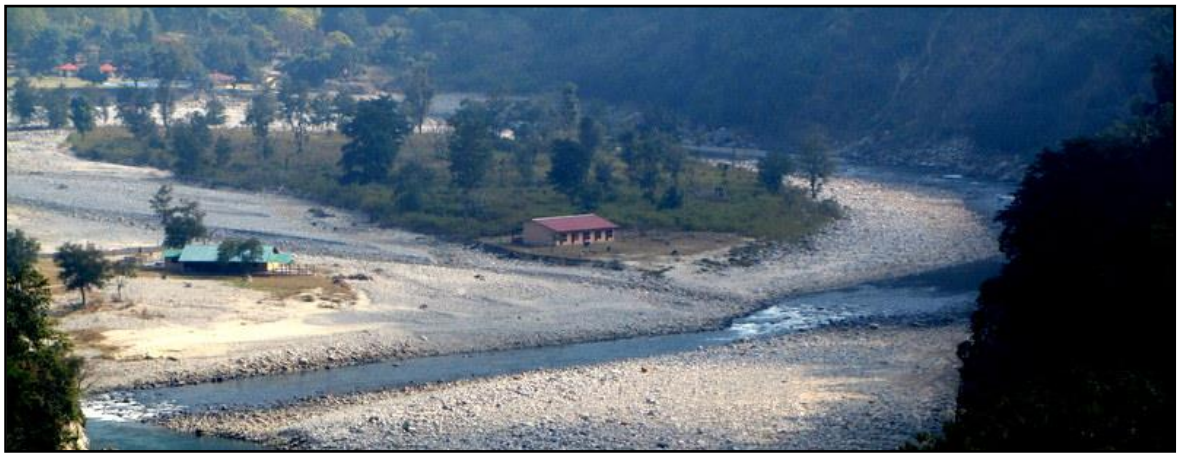
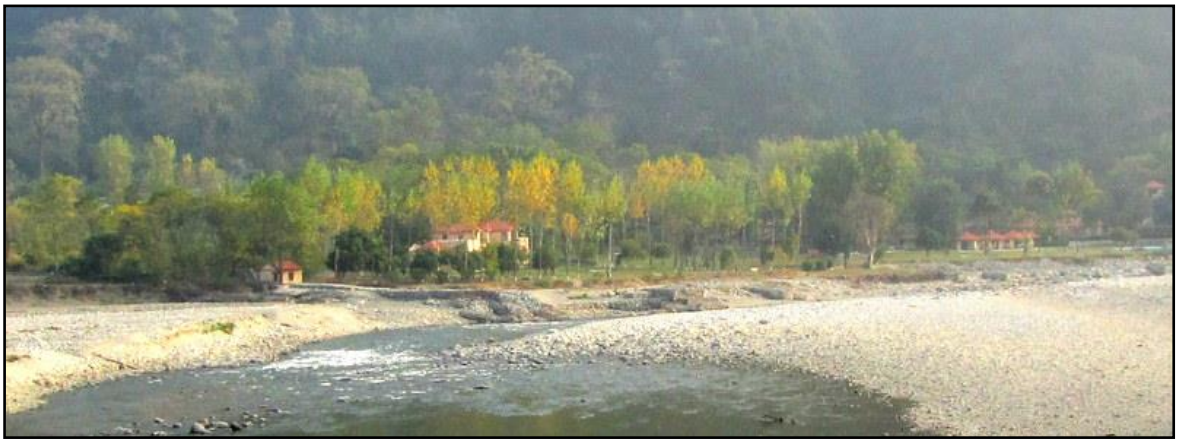


Photo 7: Existing barrage on a Himalayan river

Appendix V: Land encroachment within the buffer region of Corbett National Park (Photo credit: N. Gupta).





Appendix VI: Catch-and-release angling for the golden mahseer (*Tor putitora*) on the Ramganga River (Photo credit: The Himalayan Outback).

Appendix VII: Letters of support from the Wildlife Institute of India (WII), Dehradun.

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

No.SIVA/Ph.D Supervision/2012-13

25 May 2012

To,

The Principal Chief Conservation of Forests (Wildife) and
The Chief Wildlife Warden,
Government of Uttrakhand,
Dehradun.

Sub: Requisition of permission to conduct a Ph.D study on 'River conservation in the Himalayan Biogeographic zone' in Uttrakhand – reg

Sir,

Mr. Nishikant Gupta, Ph.D scholar from King's College London would like to carry out a study on fishes in and around the Corbett Tiger Reserve and Rajaji National Park, Uttrakhand to partially fulfil his doctoral degree on 'River conservation in the Himalayan Biogeographic zone' under the co-supervision of myself and Dr. K. Sivakumar from the Wildlife Institute of India. In this connection, may I request you to kindly grant him permission to carry out this study which would be non-invasive in nature. A copy of the proposal is enclosed for your kind perusal.

I strongly believe that the findings of his study would benefit the long term conservation of fish diversity in the state. Final findings of his study would be shared with you as soon as the project has completed.

Thanking You.

Yours faithfully,

(V.B. Mathur)
Dean
(डा0 वी0 बी0 माथुर
Dr. V. B. Mathur
संस्थान अध्यक्ष / Dean
भारतीय वन्यजीव संस्थान
Wildlife Institute of India
देहरादून / Dehradun

Encl.: As above

पत्रपेटी सं0 18, चन्द्रबनी, देहरादून – 248 001, भारत
Post Box No. 18, Chandrabani, Dehra Dun - 248001, INDIA
ई.पी.ए.बी.एक्स : + 91-135-2640111 से 2640116, फैक्स : 0135-2640117, तार : WILDLIFE
EPABX : + 91-135-2640111 to 2640116, Fax : 0135-2640117, GRAM : WILDLIFE
ई–मेल / E-mail : wii@wii.gov.in

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

23 May 2012

TO WHOMSOVER IT MAY CONCERN

This is to certify that Mr. Nishikant Gupta, is being associated with the Wildlife Institute of India to carry out his Ph.D work. You may be requested to kindly help him if he is in need of any help.

Thanking You.

(K. Sivakumar)
Scientist E
Department of Endangered Species Management
Wildlife Institute of India

पत्रपेटी सं0 18, चन्द्रबनी, देहरादून – 248 001, भारत
Post Box No. 18, Chandrabani, Dehra Dun - 248001. INDIA
ई.पी.ए.बी.एक्स : + 91-135-2640111 से 2640115 फैक्स : 0135-2640117, तार : WILDLIFE
EPABX : + 91-135-2640111 to 2640115: Fax : 0135-2640117; GRAM : WILDLIFE
ई–मेल / E-mail : wii@wii.gov.in

Appendix VIII: Letter of support from the Mahseer Conservancy, Ramnagar, Uttarakhand.

From
Sumantha Ghosh
President, Mahseer Conservancy

Dr. Michael Chadwick
Department of Geography
King's College London
Strand
London – WC2R 2LS
United Kingdom

16th March 2012

Dear Dr. Chadwick,

This is in reference to your letter regarding providing assistance to your PhD student Mr. Nishikant Gupta. I would be happy to provide all the help related to his fieldwork. Our Conservancy does similar kind of work to eradicate the serious destruction of freshwater ecosystem in part of the Ramganga.

I had a talk with Nishikant regarding this. I too hope that this would result in fruitful collaborative research.

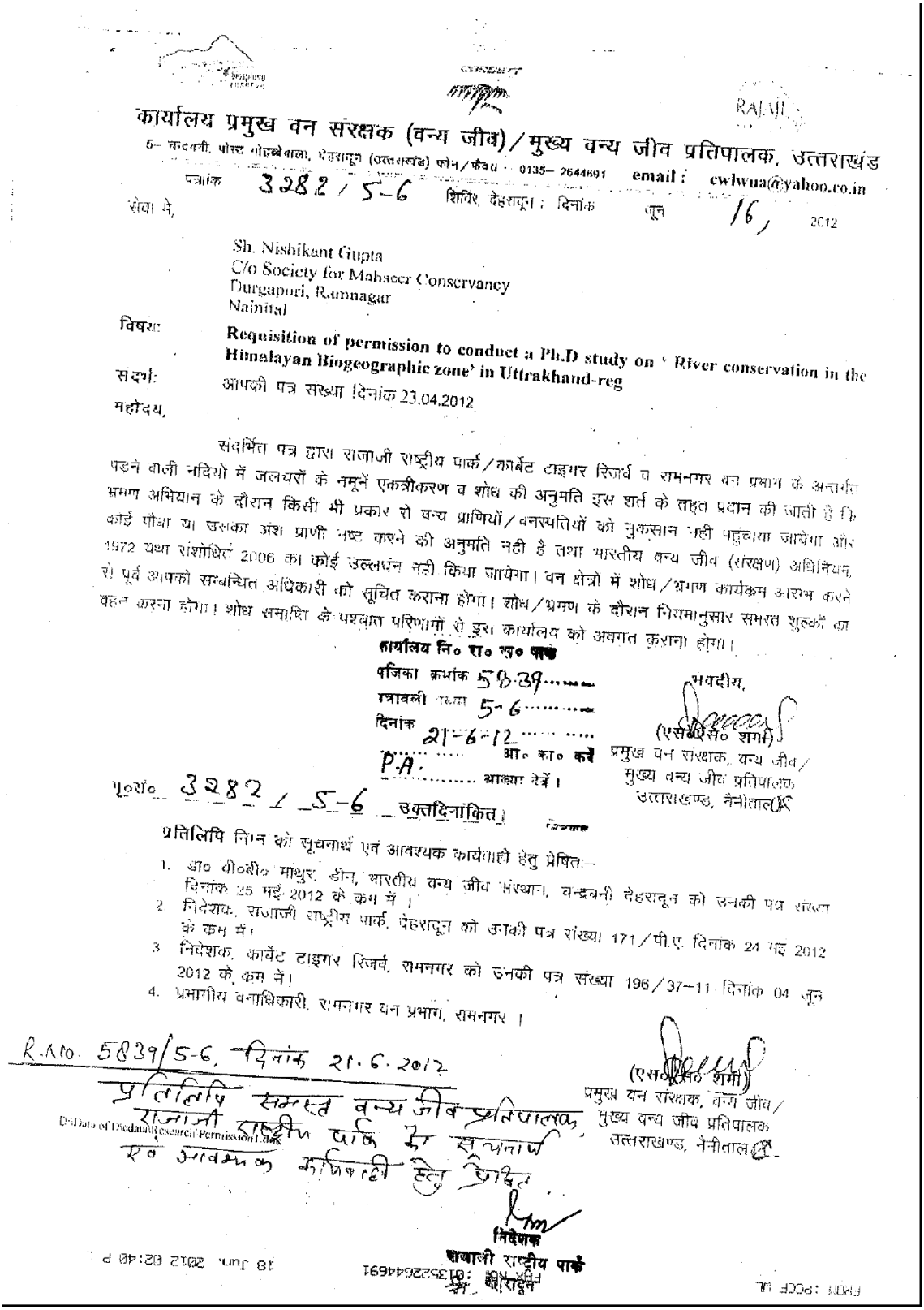
With best wishes

Sincerely

President
Society For Mahseer Conservancy
(Sumantha Ghosh)

Society for Mahseer Conservancy, Post Box No. 14, Ramnagar 244715, Nainital District, Uttarakhand, India
Mobile 0091 97611 66777, website www.mahseerconservancy.org, e-mail mahseerconservancy@gmail.com

Appendix IX: Permission letters (Chief Wildlife Warden, Uttarakhand; Directors, Corbett and Rajaji National Parks), ethical clearances (King's College London) and risk assessment forms (Department of Geography, King's College London).



कार्यालय प्रमुख वन संरक्षक (वन्य जीव)/मुख्य वन्य जीव प्रतिपालक, उत्तराखंड

5- चन्दबनी, पोस्ट गोरखेवाला, देहरादून (उत्तराखंड) फोन/फैक्स 0135- 2644691 email : cwlwua@yahoo.co.in

पत्रांक 3282 / 5-6 शिविर, देहरादून : दिनांक जून 16, 2012

सेवा में,

Sh. Nishikant Gupta
C/o Society for Mahseer Conservancy
Durgapuri, Ramnagar
Nainital

विषय: **Requisition of permission to conduct a Ph.D study on ' River conservation in the Himalayan Biogeographic zone' in Uttrakhand-reg**

संदर्भ: आपकी पत्र संख्या दिनांक 23.04.2012

महोदय,

संदर्भित पत्र द्वारा राजाजी राष्ट्रीय पार्क/कार्बेट टाइगर रिजर्व व रामनगर वन प्रभाग के अन्तर्गत पड़ने वाली नदियों में जलचरों के नमूनें एकत्रीकरण व शोध की अनुमति इस शर्त के तहत प्रदान की जाती है कि भ्रमण अभियान के दौरान किसी भी प्रकार से वन्य प्राणियों/वनस्पतियों को नुकसान नही पहुचाया जायेगा और कोई पौधा या उसका अंश प्राप्त करने की अनुमति नही है तथा भारतीय वन्य जीव (संरक्षण) अधिनियम, 1972 यथा संशोधित 2006 का कोई उल्लंघन नही किया जायेगा। वन क्षेत्रो में शोध/भ्रमण कार्यक्रम आरम्भ करने से पूर्व आपको सम्बन्धित अधिकारी को सूचित कराना होगा। शोध/भ्रमण के दौरान नियमानुसार समस्त शुल्कों का वहन करना होगा। शोध समाप्ति के पश्चात परिणामों से इस कार्यालय को अवगत कराना होगा।

कार्यालय नि० रा० ट्ग० पार्क
पंजिका क्रमांक 5839.....
पत्रावली संख्या 5-6.....
दिनांक 21-6-12.....
P.A. आ० का० करें
..... आज्ञा देवें।

(एस०एस० शर्मा)
प्रमुख वन संरक्षक, वन्य जीव/
मुख्य वन्य जीव प्रतिपालक,
उत्तराखण्ड, नैनीताल

पृ०सं० 3282 / 5-6 उक्तदिनांकित।

प्रतिलिपि निम्न को सूचनार्थ एवं आवश्यक कार्यवाही हेतु प्रेषित:-

1. डा० वी०बी० माथुर, डीन, भारतीय वन्य जीव संस्थान, चन्दबनी देहरादून को उनकी पत्र संख्या दिनांक 25 मई 2012 के क्रम में।
2. निदेशक, राजाजी राष्ट्रीय पार्क, देहरादून को उनकी पत्र संख्या 171/पी.ए. दिनांक 24 मई 2012 के क्रम में।
3. निदेशक, कार्बेट टाइगर रिजर्व, रामनगर को उनकी पत्र संख्या 196/37-11 दिनांक 04 जून 2012 के क्रम में।
4. प्रभागीय वनाधिकारी, रामनगर वन प्रभाग, रामनगर।

R.No. 5839/5-6 दिनांक 21.6.2012
प्रतिलिपि समस्त वन्य जीव प्रतिपालक, राजाजी राष्ट्रीय पार्क हेतु सूचनार्थ एवं आवश्यक कार्यवाही हेतु प्रेषित।

(एस०एस० शर्मा)
प्रमुख वन संरक्षक, वन्य जीव/
मुख्य वन्य जीव प्रतिपालक
उत्तराखण्ड, नैनीताल

निदेशक
राजाजी राष्ट्रीय पार्क
देहरादून

(12)

कार्यालय निदेशक, कार्बेट टाइगर रिजर्व, रामनगर, नैनीताल (उत्तराखण्ड)

पत्रांक– 2948 5–6 दिनांक, रामनगर, जून 27 2012

सेवा में,

समस्त वन क्षेत्राधिकारी
कार्बेट टाइगर रिजर्व
रामनगर, नैनीताल।

विषय :– **Requisition of permission to conduct a Ph.D study on 'River conservation in the HimalayanBiogeographic zone' in Uttarakhand-reg.**

संदर्भ :– प्रमुख वन संरक्षक (वन्यजीव) उत्तराखण्ड, देहरादून का पत्रांक 3282/5–6, दिनांक 16.06.12

महोदय,

उपरोक्त विषयक संदर्भित पत्र मय संलग्नकों की छायाप्रति आपको संलग्न कर भेजी जा रही है, जिसमें विभिन्न शर्तों के अन्तर्गत श्री निशिकान्त गुप्ता द्वारा सोसयटी फॉर महाशीर कंजरवेन्शी, दुर्गापुरी, रामनगर (नैनीताल) को विभिन्न नदियों में जलचरों के नमूने एकत्रीकरण व शोध की अनुमति प्रदान की गयी है। अतः तद्नुसार आवश्यक कार्यवाही करना सुनिश्चित करें।

संलग्नक : उपरोक्तानुसार।

निदेशक
कार्बेट टाइगर रिजर्व
रामनगर (नैनीताल)।

पत्रांक / तद्दिनांकित।

प्रतिलिपि निम्नलिखित को सूचनार्थ एवं आवश्यक कार्यवाही हेतु प्रेषित :–

1. उप निदेशक, कार्बेट टाइगर रिजर्व, रामनगर, नैनीताल।
2. निदेशक, कार्बेट वन्यजीव प्रशिक्षण केन्द्र, कालागढ।
3. प्रभागीय वनाधिकारी, कालागढ टाइगर रिजर्व प्रभाग, लैन्सडौन।
4. उप प्रभागीय वनाधिकारी, बिजरानी एवं कालागढ।

संलग्नक – उपरोक्तानुसार।

निदेशक
कार्बेट टाइगर रिजर्व
रामनगर (नैनीताल)।

C:\Documents and Settings\Administrator\My Documents\letter-01.doc

पत्र संख्या– 141 / 1-A

प्रेषकः

वन संरक्षक/निदेशक,
राजाजी राष्ट्रीय पार्क,
देहरादून।

सेवा में,

प्रमुख वन संरक्षक
(वन्य जीव) मुख्य वन्य जीव प्रतिपालक, उत्तराखण्ड,
शिविर कार्यालय– चन्द्रबनी,
देहरादून।

देहरादूनः दिनांकः मई 24, 2012

विषय : शोध से सम्बन्धित।

सन्दर्भ : आपका पृष्ठांकन संख्या–आर.नं. 3001/37–11, दिनांक 30–04–2012

महोदय,

उक्त विषयक श्री निशिकान्त गुप्ता, शोधार्थी के आवेदन पत्र दिनांक 23–4–2012 पर आपके सन्दर्भित पृष्ठांकन के सम्बन्ध में अवगत कराना है कि शोधार्थी को जलचरों के सम्बन्ध में वर्णित शोध की अनुमति निम्न शर्तों के अन्तर्गत प्रदान की जा सकती है :

1. शोधार्थी को किसी भी संरक्षित क्षेत्र के भीतर वन्य जीव (संरक्षण) अधिनियम, 1972 यथा संशोधित 2006 के सुसंगत प्रावधानों का पालन करना अनिवार्य होगा।
2. शोध दल द्वारा वन्य जीव (संरक्षण) अधिनियम, 1972 यथा संशोधित 2006 की धारा–12 (ख) के अन्तर्गत उभयचरों के नमूने एकत्रित किये जा सकते हैं।
3. किसी भी क्षेत्र/प्रभाग में शोध कार्य करने से पूर्व सम्बन्धित निदेशक/प्रभागीय वनाधिकारी/सक्षम अधिकारी को सम्बन्धित क्षेत्र में शोध कार्य के कार्यक्रम की पूर्व सूचना देनी अनिवार्य होगी।
4. वन विभाग की किसी भी सेवा/सुविधा अथवा आवास व्यवस्था हेतु नियमानुसार शुल्क देय होगा।
5. शोधकर्ता को शोध अध्ययन के रिपोर्ट की एक–एक प्रति आपके एवं शोध क्षेत्र से सम्बन्धित कार्यालय को उपलब्ध करानी होगी।

भवदीय,

(एस.पी. सुबुद्धि)
वन संरक्षक/निदेशक

Research Ethics Office

Research Ethics Officer
Room K0.58
The Strand
London WC2R 2LS
Tel 020 7848 1440
Email daniel.butcher@kcl.ac.uk
www.kcl.ac.uk/research/ethics

KING'S College LONDON

Nishikant Gupta,
Department of Geography
17th January 2012

Dear Nishikant,

REP(GGS)/11/12-15 'Utility of Protected Areas for the conservation of rivers in India.'

I am pleased to inform you that the above application has been reviewed by the GGS Research Ethics Panel that FULL APPROVAL is now granted.

Please ensure that you follow all relevant guidance as laid out in the King's College London Guidelines on Good Practice in Academic Research (http://www.kcl.ac.uk/college/policyzone/index.php?id=247).

For your information ethical approval is granted until 16/01/13. If you need approval beyond this point you will need to apply for an extension to approval at least two weeks prior to this explaining why the extension is needed, (please note however that a full re-application will not be necessary unless the protocol has changed). You should also note that if your approval is for one year, you will not be sent a reminder when it is due to lapse.

Ethical approval is required to cover the duration of the research study, up to the conclusion of the research. The conclusion of the research is defined as the final date or event detailed in the study description section of your approved application form (usually the end of data collection when all work with human participants will have been completed), not the completion of data analysis or publication of the results. For projects that only involve the further analysis of pre-existing data, approval must cover any period during which the researcher will be accessing or evaluating individual sensitive and/or un-anonymised records. Note that after the point at which ethical approval for your study is no longer required due to the study being complete (as per the above definitions), you will still need to ensure all research data/records management and storage procedures agreed to as part of your application are adhered to and carried out accordingly.

If you do not start the project within three months of this letter please contact the Research Ethics Office.

Should you wish to make a modification to the project or request an extension to approval you will need approval for this and should follow the guidance relating to modifying approved applications: http://www.kcl.ac.uk/research/ethics/applicants/modifications.html
The circumstances where modification requests are required include the addition/removal of participant groups, additions/removal/changes to research methods, asking for additional data from participants, extensions to the ethical approval period. Any proposed modifications should only be carried out once full approval for the modification request has been granted.

Research Ethics Office

Research Ethics Officer
Room K0.58
The Strand
London WC2R 2LS
Tel 020 7848 1440
Email daniel.butcher@kcl.ac.uk
www.kcl.ac.uk/research/ethics

KING'S College LONDON

Any unforeseen ethical problems arising during the course of the project should be reported to the approving committee/panel. In the event of an untoward event or an adverse reaction a full report must be made to the Chair of the approving committee/review panel within one week of the incident.

Please would you also note that we may, for the purposes of audit, contact you from time to time to ascertain the status of your research.

If you have any query about any aspect of this ethical approval, please contact your panel/committee administrator in the first instance (http://www.kcl.ac.uk/research/ethics/contacts.html). We wish you every success with this work.

With best wishes

Yours sincerely

D G Butcher

Daniel Butcher
Research Ethics Officer

Research Ethics Office

5.11 Franklin Wilkins Building
(Waterloo Bridge Wing)
Stamford Street
London SE1 9NH
Tel 020 7848 4077/4070/3758
Email rec@kcl.ac.uk
www.kcl.ac.uk/research/ethics

KING'S College LONDON

Nishikant Gupta
Department Of Geography

12th November 2013

Dear Nishikant,

REP (GSSHM)/13/14-2 'Recreational angling as a conservation tool for river and fish conservation.'

Review Outcome: Full Approval

I am pleased to inform you that the above application has been reviewed by the GGSHM Research Ethics Panel and that FULL APPROVAL is now granted.

Please ensure that you follow all relevant guidance as laid out in the King's College London Guidelines on Good Practice in Academic Research (http://www.kcl.ac.uk/college/policyzone/index.php?id=247).

For your information ethical approval is granted until **11/11/2015**. If you need approval beyond this point you will need to apply for an extension to approval at least two weeks prior to this explaining why the extension is needed, (please note however that a full re-application will not be necessary unless the protocol has changed). You should also note that if your approval is for one year, you will not be sent a reminder when it is due to lapse.

Ethical approval is required to cover the duration of the research study, up to the conclusion of the research. The conclusion of the research is defined as the final date or event detailed in the study description section of your approved application form (usually the end of data collection when all work with human participants will have been completed), not the completion of data analysis or publication of the results. For projects that only involve the further analysis of pre-existing data, approval must cover any period during which the researcher will be accessing or evaluating individual sensitive and/or un-anonymised records. Note that after the point at which ethical approval for your study is no longer required due to the study being complete (as per the above definitions), you will still need to ensure all research data/records management and storage procedures agreed to as part of your application are adhered to and carried out accordingly.

If you do not start the project within three months of this letter please contact the Research Ethics Office.

Should you wish to make a modification to the project or request an extension to approval you will need approval for this and should follow the guidance relating to modifying approved applications:
http://www.kcl.ac.uk/innovation/research/support/ethics/applications/modifications.aspx
The circumstances where modification requests are required include the addition/removal of participant groups, additions/removal/changes to research methods, asking for additional data from participants,

Research Ethics Office

5.11 Franklin Wilkins Building
(Waterloo Bridge Wing)
Stamford Street
London SE1 9NH
Tel 020 7848 4077/4070/3758
Email rec@kcl.ac.uk
www.kcl.ac.uk/research/ethics

KING'S College LONDON

extensions to the ethical approval period. Any proposed modifications should only be carried out once full approval for the modification request has been granted.

Any unforeseen ethical problems arising during the course of the project should be reported to the approving committee/panel. In the event of an untoward event or an adverse reaction a full report must be made to the Chair of the approving committee/review panel within one week of the incident.

Please would you also note that we may, for the purposes of audit, contact you from time to time to ascertain the status of your research.

If you have any query about any aspect of this ethical approval, please contact your panel/committee administrator in the first instance (http://www.kcl.ac.uk/innovation/research/support/ethics/contact.aspx). We wish you every success with this work.

Yours Sincerely,

Annah Whyton
Research Support Assistant

Department of Geography
King's College London
Strand Campus
London WC2R 2LS

Individual Fieldwork Risk Assessment Form (Staff and Students)

*Note: Please read the 'Department of Geography, Code of Conduct for Safety in the Field'. This form should be completed electronically, printed in triplicate, the three copies signed and countersigned, and lodged with your supervisor, the Department Office and one for retention by yourself **before** fieldwork commences. This form must be completed for **any and all fieldwork** taking place outside the Department of Geography including laboratory work outside College premises.*

Name	Nishikant Gupta
Project title	Fieldwork to investigate the utility of Protected Areas for the conservation of rivers in India
Dates	01/03/2012 - 31/07/2012
Location	Sites along the 7 rivers (Rishi Ganga, Bhagirathi, Ganga, Son, Ramganga, Tons & Pushpavati) flowing through the 6 National Parks (Gangotri, Govind, Nanda Devi, Valley of Flowers, Corbett and Rajaji) of the Indian Himalayan bio-geographic zone
Contact address	King's College London, Department of Geography, Strand, London - WC2R 2LS
Contact phone	02070873007
Mobile phone	07538557921

Checklist

Have all necessary permissions been sought and documents obtained?	YES
Have all vehicle drivers been properly instructed and their eligibility to drive checked?	YES
Has adequate insurance been obtained in accordance with College regulations? (application form http://www.kcl.ac.uk/geography/internal/forms/travel_insurance.pdf)	YES

Signature of Fieldworker

Nishikant Gupta.

Countersignature *(Students – Research Supervisor, Research Staff – Project Leader, Academic Staff – Head of Department)*

Name of Countersignatory Dr. Michael Chadwick MChadwick

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3 RISK ASSESSMENT FORM AND ASSOCIATED DOCUMENTATION

This page must be completed for all fieldwork taking place outside the Department of Geography, any laboratory work inside the College premises and ALL student dissertation projects, whether human or physical, and whether undergraduate, postgraduate taught or postgraduate research.

AFTER reading through ALL risk categories, please sign RISK TYPE A or B below, which applies to you.

RISK TYPE A. I have considered ALL categories in this form and I declare that I am undertaking a student project/dissertation where NONE of my research will be outside of college premises or home, and will not involve any of the risks identified in ANY of the categories of this risk assessment form. For example, the research wholly involves library/archival research or analysis of existing on-line/other data. None of the risks of my project/dissertation are greater than in everyday life and normal activities. Should my research project change, such that there risks involved, it is my responsibility to fill out this form appropriately and obtain the appropriate signatures for Risk Type B.

SIGNATURES OF PERSON FILLING IN A RISK ASSESSMENT AND COUNTERSIGNATURE.
A. Person filling in this risk assessment
Name (Typed or printed in BLOCK letters):
Signature:
Date:
B. Countersignature and date (Students – Research Supervisor; Research Staff – Project Leader; Academic Staff – Head of Department)
Name (Typed or printed in BLOCK letters):
Signature:
Date:

Print this page in triplicate; the three copies signed and countersigned, and lodged with:
(1) Your supervisor.
(2) The Department Office.
(3) One for retention by yourself.
For UGT and PGT students, this signatures page of your risk assessment must be included in Appendix 1 of your dissertation.

RISK TYPE B. I have considered ALL categories in this form, indicated which risks apply to me that are greater than in everyday life and normal activities (writing yes/no for every section), for those sections where I have answered 'yes' I have indicate the degree of risk from 1–5 (1=low, 5=high), where appropriate added notes and indicated other additional risks in the final section.

SIGNATURES OF PERSON FILLING IN A RISK ASSESSMENT AND COUNTERSIGNATURE.
A. Person filling in this risk assessment
Name (Typed or printed in BLOCK letters): NISHIKANT GUPTA
Signature: Nishikant Gupta
Date: 10/09/2012
B. Countersignature and date (Students – Research Supervisor; Research Staff – Project Leader; Academic Staff – Head of Department)
Name (Typed or printed in BLOCK letters): DR. MICHAEL CHADWICK
Signature: Michael A Chadwick
Date: 20/09/2012

All pages in this form except for p. 1 should be printed in triplicate, the three copies signed and countersigned, and lodged with:
(1) Your supervisor.
(2) The Department Office.
(3) One for retention by yourself before fieldwork commences.
For UGT and PGT students, this signatures page of your risk assessment must be included in Appendix 1 of your dissertation.

For work outside of the UK, please do not forget to obtain insurance in accordance with College regulations (application form http://www.kcl.ac.uk/about/structure/admin/finance/staff/insurance/travel.html).

3 RISK ASSESSMENT FORM AND ASSOCIATED DOCUMENTATION

After reading through ALL risk categories, please select RISK TYPE A or B below.

RISK TYPE A

You are only eligible for RISK TYPE A if all of the following are true:

- **Your work take place within: college premises or home or within organizations/premises that have their own clear risk assessment in place.**
- **Your work involves ONLY library/archival data or existing on-line/other data.**
- **Your work WILL NOT expose you to risks greater than in everyday life.**

DECLARATION: I have considered ALL categories in this form and I declare that I am undertaking a student project/dissertation where: a) NONE of my research will be outside of college premises or home or organizations/premises that have their own clear risk assessment in place; and b) it does not involve ANY of the risks identified in ANY of the categories of this risk assessment form. Should my research project change, such that there are now risks involved, then it is my responsibility to resubmit this form after completing an assessment for Risk Type B.

SIGNATURES OF PERSON FILLING IN A RISK ASSESSMENT AND COUNTERSIGNATURE.
A. Person filling in this risk assessment
Name (Typed or printed in BLOCK letters): NISHIKANT GUPTA
Signature: Nishikant Gupta
Date: 02.09.2013
B. Countersignature and date
(Students – Research Supervisor; Research Staff – Project Leader; Academic Staff – Head of Department)
Name (Typed or printed in BLOCK letters): DR. MICHAEL CHADWICK
Signature:
Date: 02.09.2013

Print this page in triplicate; the three copies signed and countersigned, and lodged with:
(1) Your supervisor.
(2) The Department Office.
(3) One for retention by yourself.
For UGT and PGT students, this signatures page of your risk assessment must be included in Appendix 1 of your dissertation.

RISK TYPE B

Fill out THIS PAGE and ALL OTHER PAGES in this form.

DECLARATION: I have considered ALL categories in this form and have indicated which risks apply to me that are greater than in everyday life and normal activities (writing yes/no for every section). Where I have answered 'yes' then I have also indicated the degree of risk from 1–5 (1=low, 5=high) and, where appropriate, added notes or comments relating to the level of risk. I have identified and added any additional risks not explicitly covered by this form in the final section.

SIGNATURES OF PERSON FILLING IN A RISK ASSESSMENT AND COUNTERSIGNATURE.
A. Person filling in this risk assessment
Name (Typed or printed in BLOCK letters): NISHIKANT GUPTA
Signature: Nishikant Gupta
Date: 02.09.2013
B. Countersignature and date
(Students – Research Supervisor; Research Staff – Project Leader; Academic Staff – Head of Department)
Name (Typed or printed in BLOCK letters): DR. MICHAEL CHADWICK
Signature:
Date: 02.09.2013

All pages in this form should be printed in triplicate; the three copies signed and countersigned, and lodged with:
(1) Your supervisor.
(2) The Department Office.
(3) One for retention by yourself before fieldwork commences.
For UGT and PGT students, this signatures page of your risk assessment must be included in Appendix 1 of your dissertation.

For work outside of the UK, please do not forget to obtain insurance in accordance with College regulations (application form https://internal.kcl.ac.uk/about/ps/finance/treasry/insure.aspx).

Appendix X: Recreational Angling Survey

The aim of this survey is to determine the extent to which there is support from the recreational angling community in India for river and fish conservation.

1) What is your age?

2) What is your gender?

3) Which organization do you have main affiliation with?

4) On average, how many days do you fish per year in India?

5) Which Indian State/Union Territory do you live in?

6) Which Indian State/Union Territory do you mostly fish in?

7) How many days did you fish over the past year (June 1st 2013 to May 31st 2014) in this State/Union Territory?

8) Which is your main target fish species during angling?

9) Which is your preferred angling method?

10) Regarding your angling experience, which factor is most important to you?

11) In your opinion, which threat is impacting your target fish species and your leisure experience the most?

12) Which conservation effort do you feel need to be implemented to protect and conserve the fish biodiversity in India?

13) Have you witnessed destructive fishing techniques first hand at/near your angling location?

14) What were these destructive fishing techniques?

15) How much money do you spend per year towards recreational angling activities (in Indian Rupees)?

16) How many fish do you catch each year?

17) What percentage (%) of those fish do you release back into the water?

18) How aware are you of the conservation status, e.g., endangered/vulnerable/near-threatened of the fish species you target?

19) Do you think that recreational angling can benefit the conservation of fish species in Indian rivers?

20) Please explain your answer to the above.

21) How willing would you be to get involved in a conservation initiative in your angling region?

22) Would you be willing to contribute your time and money for such an initiative?

23) Any additional comments/concerns.

Appendix XI: Catch-and-release angling survey questionnaire.

This questionnaire aims to investigate the available positive support from the catch-and-release angling community for river and fish conservation on a global scale. The data gathered will be used for an article which will highlight a possible two-pronged approach where research scientists and catch-and-release anglers work together to bring about conservation benefits.

1) What is your age?

Under 18
Between 18 - 24
Between 25 - 34
Between 35 - 44
Between 45 - 54
Between 55 - 64
Over 65

2) Sex

Male
Female

3) Nationality

4) Which of these international/national organizations do you have affiliation(s) with?

Wildlife Association of South India (WASI)
Mahseer Trust
The Himalayan Outback
Coorg Wildlife Society
WWF
Angling Trust
AIGFA
MSAA
IGFA
The Billfish Institute
Other:

5) On average, how many angling excursions do you make per year in your own country?

None
1 - 3
4 - 6
7 - 10
11 - 20
Over 20

6) On average, how many angling excursions do you make per year outside your own country?

None
1 - 3
4 - 6
7 - 10
11 - 20
Over 20

7) Which of these continents have you visited for recreational angling activities?

North America
South America
Australia
Asia
Africa
Europe
Antarctica

8) Which of these Asian countries have you visited for recreational angling activities?

India
Malaysia
Sri Lanka
Nepal
Indonesia
Other:

9) If in India, which of these rivers do you target?

Cauvery
Kali
Ramganga
Other:

10) In Asia, which of these are your main target fish species?

Mahseer
Cat fishes (Goonch)
Marine species
Other:

11) Which of these do you prefer as your angling method?

Bait
Live/dead bait
Lure/spinner
Fly

12) Regarding your angling experience, are the below-mentioned factors important to you?

Angling quality
Aesthetics of surroundings
Other wildlife
Catch and release (suitable fishery management practices)
Camp infrastructure
Inclusion of and financial benefit to local communities

13) Have you observed a change in angling quality over the years?

Yes
No

14) What are these changes?

Positive changes
Negative changes
No change

15) In your opinion, are the below-mentioned threats impacting your target fish species, and your leisure experience?

Deforestation
Water abstraction
Hydro projects (flow regulation)
Water pollution
Destructive fishing techniques

16) Do you feel the below-mentioned conservation efforts need to be implemented to protect and conserve the fish biodiversity in the region?

Afforestation
Legislation protecting threatened species
Scientific research (enhance understanding of population trends and key habitat requirements)
Effective anti-poaching patrol
Harsher fines for culprits
Education
Stocking

17) Have you witnessed destructive fishing techniques first hand?

Yes
No

18) How much money do you spend annually towards recreational angling activities (in £)?

0
1 - 3000
3001 - 6000
6001 - 9000
9001 - 12000
Above 12001

19) How aware are you of the conservation status (IUCN Red List) of the fish species you target?

Strongly unaware
Unaware
Neither aware nor unaware
Aware
Strongly aware

20) Do you think that recreational angling can benefit the conservation of threatened species?

Yes
No

Please explain your answer to the above.

21) How willing would you be to get involved in a conservation initiative in your angling region?

Very interested
May be
Not at all interested

22) Would you be willing to contribute your time and money for such an initiative?

Yes, time and money both
Yes, but only time
Yes, but only money
Neither time nor money

23) Any additional comments.