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An assessment of fish diversity of Kuwano River (A tributary of river Ghaghara), emerging threats and conservation perspectives

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Abstract
Freshwater ecosystems and their biodiversity are one of the most endangered and inadequately protected aquatic resources worldwide with nearly one in three freshwater species facing a high risk of extinction. First time, we documented and described the ichthyofaunal diversity of Kuwano River, Uttar Pradesh, including a systematic updated checklist, vernacular names and the current status of IUCN status. Altogether 56 finfish species representing 7 orders, 22 families and 40 genera were recorded. Among these, 48 species belonged to the Least Concern (LC), two species belonged to the Near Threatened (NT) and Not Evaluated categories of the IUCN Red List. *Wallago attu, Bagarius bagarius* and *Cyprinus carpio were* listed in the vulnerable (VU) while *Clarius magur* comes under the Endangered (EN) category of the IUCN Red List, 2023. Presently, this river and its fauna are under severe ecological degradation due to several anthropogenic issues. Major threats in the study area are unmanaged and unregulated fishing, illegal fishing approaches, growth and recruitment overfishing, siltation, aquatic pollution, exotic species and infestation of invasive alien plants such as water hyacinth *(Eichhornia crassipes)* etc. There is no documentary record available of the present study area till the date regarding its diversity. Thus, an urgent need exists for taking up research on the priority fish fauna and their habitat characterization. Restoration measures have been proposed based on an ecosystem-scale approach to biodiversity conservation. Moreover, there is a need to maintain this valuable river to be environmentally friendly for the aquatic fauna and flora to thrive. This result is expected to contribute skeletal information for future studies in this ecosystem.

Keywords: Riverine, ecosystem, fish, diversity, Uttar Pradesh

Introduction
The freshwater ecosystem is one of the most vulnerable and threatened habitats in the world (Dudgeon 2011; Cooke *et al*., 2016; Sahu *et al*., 2023) [31, 2, 32]. Although freshwater ecosystems such as rivers, lakes and wetlands cover less than 2% of the earth's surface, provide a wide range of habitats for a significant proportion of plants and animals. Unfortunately, the diversity of freshwater ecosystems has seen a constant decline in the last few decades due to the destruction of habitat on account of several threats and human interference (Dudgeon *et al*., 2006; Sarkar *et al*., 2008) [33, 28]. Freshwater habitats are declining much faster than terrestrial ecosystems due to climate change, overexploitation, indiscriminate fishing, aquatic pollution, river flow modification, construction of dams, diversion or reclamation of river beds for urbanization, habitat degradation, and exotic species invasion etc. Therefore, there is an urgent need to initiate conservation measures to protect the indigenous and threatened fish species. Minimize human encroachment in aquatic ecosystems and sustainable utilization of water resources.
Freshwater fish fauna are the most threatened & endemic vertebrate group with more than 34,000 known species worldwide that are continuously depleted and many freshwater species have become threatened. Recently, 20% of the world's freshwater fish is vulnerable, endangered or extinct (Revenga *et al*., 1998) [34]. Globally, the freshwater ecosystem is home to 36,640 valid fish species, including 18,614 (Eschmeyer's Catalog of Fishes, 2023).
Uttar Pradesh is diverse and blessed with vast potential of aquatic resources that exhibit rich genetic and vivid freshwater fish diversity that contributes nearly 14.68% of Indian fish diversity. These natural aquatic resources harbouring a variety of fishes exist in the form of rivers, lakes, reservoirs, wetlands, ponds and tanks. However, due to increasing anthropogenic stress, these aquatic water bodies declining rapidly.

Fish distribution and abundance from different parts of Uttar Pradesh have been evaluated by different authors (Sahu *et al*., 2023; Sarkar *et al*., 2010; Mishra *et al*., 2011; Serajuddin *et al*., 2004; Sarkar *et al*., 2008) [32, 26, 15, 30, 28]. The exclusive literature survey indicates that there is no information is available on the pattern of fish diversity in the Kuwano River except paper on Water Quality parameters (Kushwaha *et al*., 2021) [35]. To date, no previous study on finfish in this river was carried out.

There is a considerable knowledge gap on the fish diversity patterns in many riverine ecosystems of Uttar Pradesh, notably in the case of smaller systems such as the Kuwano River. Considering this lacuna, the present study focuses on presenting a checklist of fish study assemblage structure, assessing the abundance, diversity, distribution, and richness of fish fauna from River Kuwano, Basti district. And also suggesting proper management strategies for the conservation of fish diversity in the study area. This will serve as a baseline for the finfish diversity and will facilitate future ichthyofaunal surveys, monitoring and biodiversity studies.

Materials and Methods

Study area: Kuwano River (also called West Rapti) is a small tributary of the Ghaghra River (Saryu), which originates from the Terai region as a spring near Basaupur village in Bahraich district, Uttar Pradesh. The river flows through Bahraich, Balrampur, Gonda, and Basti joins in Budhi Rapti at Sant Kabirnagar and finally joins in the Ghaghara River at Gorakhpur district. There is a dam on this river at Mukhlishpur. The river is also known for flooding during the rainy season. Apart from Sal and Teak, rare species of Cirrus tree are found here. There is a long chain of bushes on both sides of the river which is also rare. Due to the slow flow of water, many floating weeds are also found in this river.

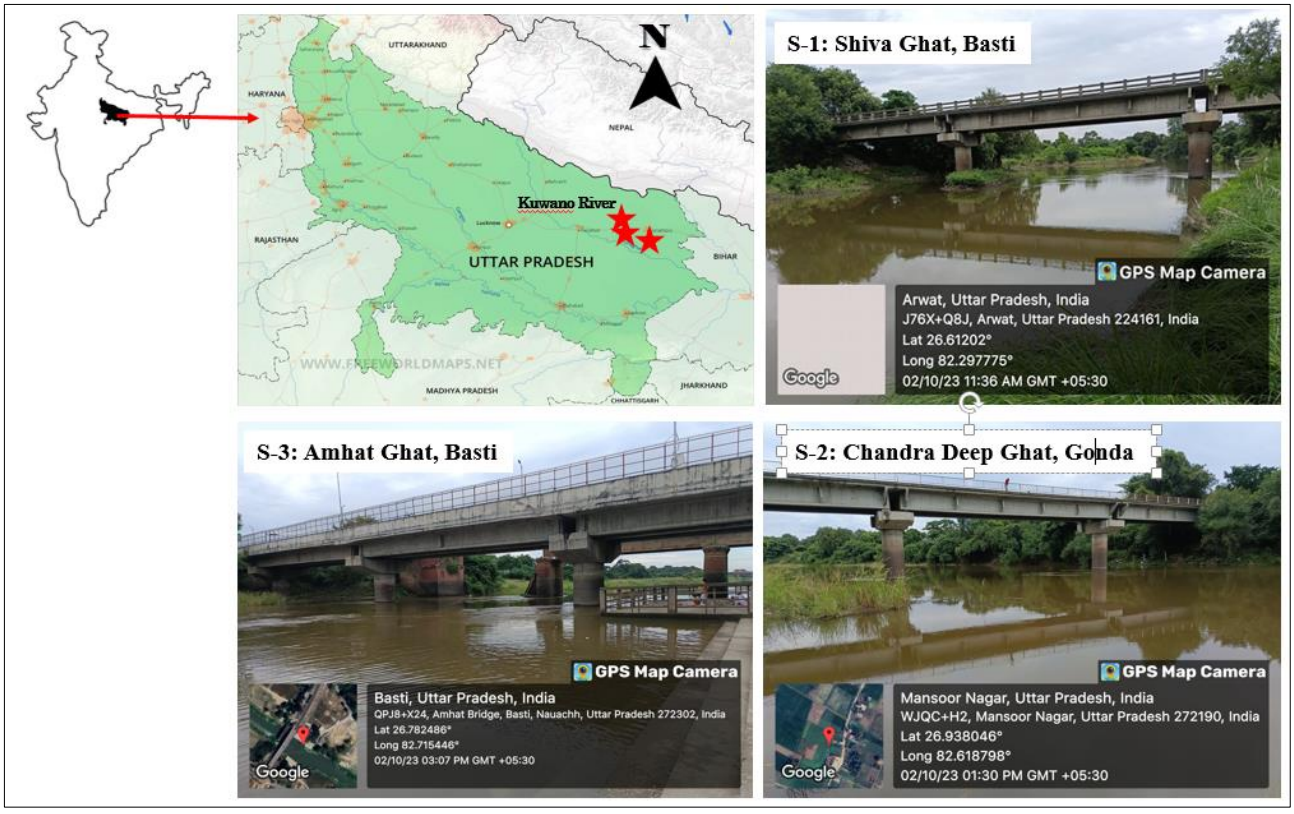

Fig 1: Map showing the different sites in Kuwano River, Uttar Pradesh

Table 1: Sampling Sites and Their Physical Attributes

Sl. No.	Site Code	Sampling station	Stream reach	Latitude	Longitude
1.	S-1	Shiva Ghat, Basti	Upper stretch	56' 16.9656" N	82° 37' 7.6728" E
2.	S-2	Chandra Deep Ghat, Gonda	Upper stretch	26° 36' 43.272" N	82° 17' 51.99" E
3.	S-3	Amhat Ghat, Basti City	Middle stretch	26° 46' 56.9496" N	82° 42' 55.602" E

Collection of samples: The finfish were observed in the sampling site during the year April 2023 to September 2023. Fish samples were collected on a quarterly basis using standard fishing gears like cast net, drag net, and hand/ dip net of different mesh sizes. We also visited fish markets and landing centers associated with the river stretch to assess and verify the presence of fish species which did not come to our net. Collected samples were immediately preserved in 5% formalin for further study. Fishes were identified following Day (1878) [36], Talwar & Jhingran (1991) [37], Jayaram (1981, 1999) [8], Kottelat (2001) [38] and Gopalji Srivastava (2000) [39]. The colour, banding patterns, morphometric and meristic characters were studied as fin formulas of each species. Updated taxonomic framework and nomenclature were collected from the FAO-Fish base database, Eschmeyer's Catalog of Fishes, World Register of Marine Species (WoRMS) and Aquatic Genetic Information System of India (AqGRISI). It is very important to know the conservation status of fish diversity for taking future strategies to maintain the sustainability of this riverine ecosystem. For ascertaining the conservation status of the ichthyo species is based on IUCN (2023).

Relative Abundance: Abundance represents the relative representation of a species in a particular area and was calculated using the formula,

$$\text{Relative Abundance (RA) (\%)} = \frac{\text{Number of individuals per species x100}}{\text{Total number of individuals}}$$

Evaluation of Fish diversity indices: Plymouth Routines in Multivariate Ecological Research (PRIMER v6) software (Clarke and Warwick, 2001) [40] and Microsoft Excel (MS Excel) were used for diversity analysis. Diversity indices like Shannon-Wiener index (H′), Margalef's index (d), Pielou's evenness index (J'), Simpson's dominance (λ), and Simpson's diversity (1-λ) were estimated in order to interpret species richness and the species abundance data (table).

Table 2: Diversity Indices and formula

Sr. No.	Diversity Indices	Formula
1.	Shannon-Wiener diversity index (H')	$H = \sum P_i \text{ In } P_i$ or $_i \log_e P_i$
2.	Margalef richness index (d)	D= D(S-1) / log N
3.	Pielou's evenness index (J')	J' = H'/ In S
4.	Simpson dominance index (λ)	$\lambda = \sum pi^2$, pi (ni/N)
5.	Simpson diversity index (1- λ)	$1- \lambda = \sum pi^2$, pi (ni/N)

Where,
H'= Species diversity in bits of information per individual
Pi = S/N
S = number of species
N = total number of individuals in collection
In = logarithm to base e
J'= Evenness
ni = number of individuals of taxon i1, i2 etc.

Statistical analysis diversity and community structure: PRIMER (Plymouth Routines in Multivariate Ecological Research, version 6.1.9) for Windows (Clarke & Gorley 2006; Clarke & Warwick 2001) [41, 40] was used for biodiversity analysis. Quantitative and qualitative analysis of diversity was done using various diversity measures and diversity indices described below.

Results and Discussion

The Inventory of finfish identified species from Kuwano River along with IUCN conservation status are presented in Table 2. A total of 56 finfish belong to 7 orders, 23 families and 40 genera. According to the IUCN Red List (2023), most of the fish species recorded under the least concern (LC) so far from the conservation point of view. Two species belonged to the Not Evaluated (NE) and three Vulnerable (VU) categories of the IUCN list. However, *Clarius magur* is Endangered (EN), while *Hypophthalmichthys molitrix* and *Chitala chitala* are near threatened (NT) (Fig 6). All the identified fishes were recorded under Plates 1, 2, 3 and 4.

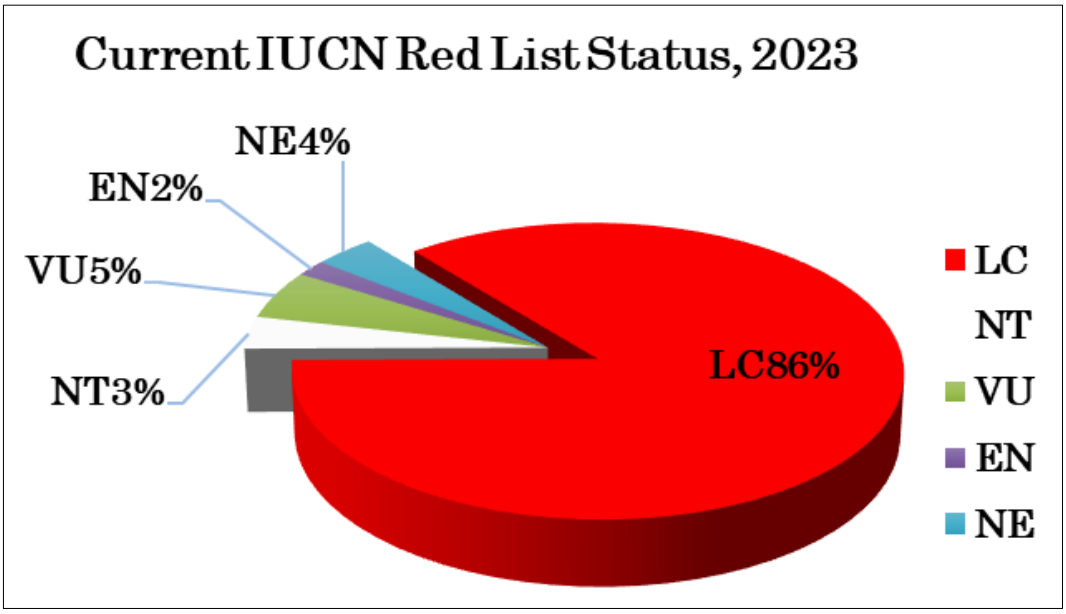

Fig 2: IUCN conservation status of fish species recorded from Kuwano River

Seven orders of finfishes, Cypriniformes, Siluriformes, Perciformes, Synbranchiformes, Osteoglossiformes, Gobiiformes and Beloniformes were recorded from the study area. Order Cypriniformes (44.64%), Perciformes (21.43%) and Siluriformes (19.64%) comprised the maximum number of species whereas order Gobiiformes and Beloniformes formed 1.79% of the total finfishes recorded.

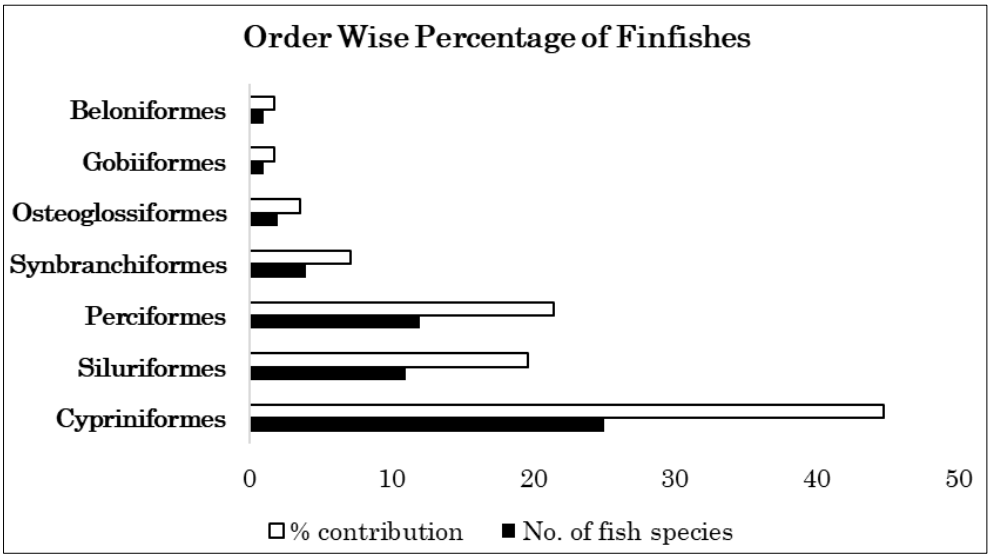

Fig 3: Order-wise contribution of finfishes of Kuwano River, Uttar Pradesh

The present studies revealed that 22 families of finfish were represented in the Kuwano River, Uttar Pradesh. They included Cyprinidae, Danionidae, Cobitidae, Botiidae, Nemacheilidae, Siluroidae, Bagridae, Sisoridae, Heteropneustidae, Claridae, Channidae, Ambassidae, Anabantidae, Cichlidae, Badidae, Nandidae, Osphronemidae, Mastacembelidae, Synbranchidae, Notopteridae, Gobioidae and Belonidae. Among these Cyprinidae contributed the highest number with 28.57% followed by Danionidae (10.71%), Channidae and Badidae (7.14%) (Fig.). Similarly, studies on several Indian rivers also showed (Sarkar *et al*., 2008; Heda, 2009) [28, 7].

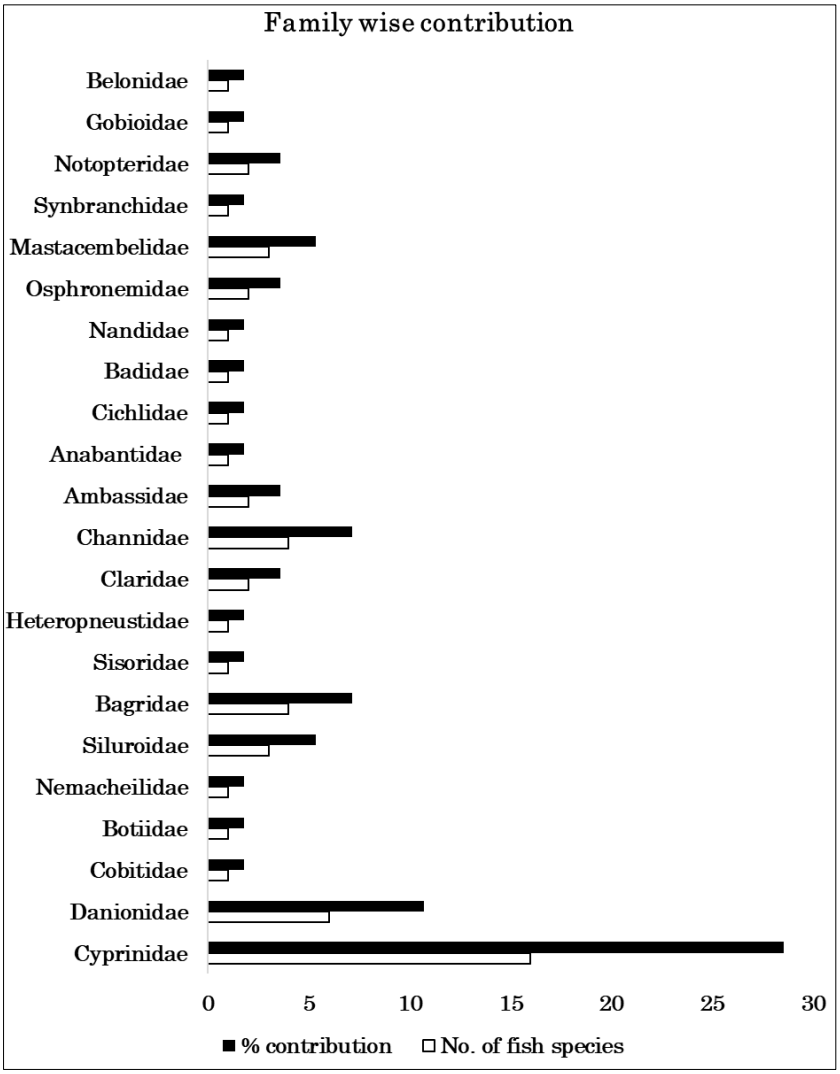

Fig 4: Family-wise contribution of finfishes of Kuwano River, Uttar Pradesh

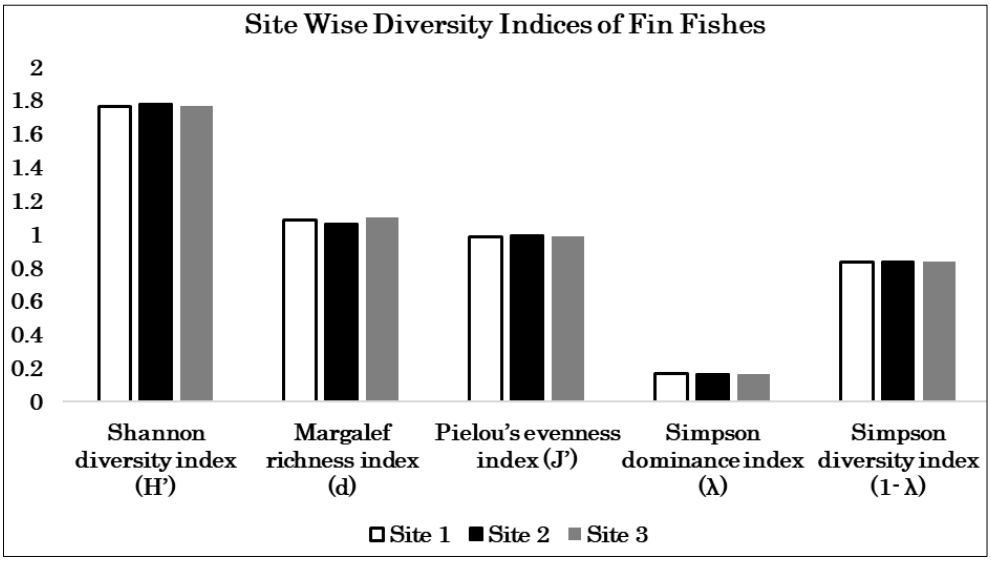

Fig 5: Site-wise diversity indices of fin fishes of the Kuwano River

The Shannon diversity index (H′) and evenness (J) values were computed for all three sites of Kuwano River. The maximum Shannon diversity index (1.78) was computed at site 2, whereas sites 1 and 3 had the lowest value (1.76). The highest margalef richness index (d) (1.1) was reported from site 3 while the lowest (1.06) was from site 2. The highest Pielou's Evenness index (J') was quantified at sites 2 (0.99), and the lowest at sites 1, 3 (0.98). Site 1 shows a maximum (0.166) Simpson Dominance Index (λ) whereas, site 2 represents the maximum value (0.837) of the Simpson Diversity Index (1- λ). (Fig.).

Table 1: Different Diversity Indices of Fishes in Kuwano River

Sites	No. of Individuals	No. of Species	Relative Abundance (RA %)	Shannon Diversity Index (H')	Margalef Richness Index (d)	Pielou's Evenness Index (J')	Simpson Dominance Index (λ)	Simpson Diversity Index (1- λ)
Site 1	100	18	35.20	1.765	1.086	0.9851	0.1667	0.8333
Site 2	110	21	27.73	1.78	1.064	0.9936	0.1628	0.8372
Site 3	94	16	37.07	1.766	1.101	0.9857	0.1663	0.8337

There is no previous study of fish fauna in this river was found and thus comparison of the present findings with the previous one was not possible. According to local fishermen and the community, over the past decade, the Kuwano River ecosystem has experienced significant changes in its finfish population. The introduction of five exotic fish species, including *Clarias gariepinus, Cyprinus carpio, Oreochromis niloticus, Hypophthalmichthys molitrix,* and *Ctenopharyngodon idella* has triggered a significant shift in the balance of this ecosystem. The introduction of these exotic species has fomented fierce competition, one in which the native Indian Major Carps (IMC) and other indigenous fish groups have been the primary casualties. This fierce rivalry for resources, including food & habitat, has culminated in a stark and precipitous decline in the populations of native fishes. Similar comments were also made by several researchers (Sarkar *et al*., 2010; Lakra, 2010; Sandilyan, 2016; Das *et al*., 2020) [26, 13, 23, 3].

Major Threats to Kuwano River Ecosystems

River ecosystems are essential components of our natural environment, providing habitat for various species and serving as sources of freshwater for human consumption & agricultural purposes. However, these vital ecosystems face numerous threats that can compromise their health and sustainability. Effective fisheries management is crucial to mitigate these threats and ensure the preservation of river ecosystems. According to the local fishermen, many species of fish, which were abundant in past years, showed a decline in recent catches, due to destruction and degradation of their habitat by ecological and man-made interventions, which are described below.

Habitat Destruction: One of the most significant threats to this river ecosystem is habitat destruction due to urban development, agriculture, and infrastructure projects often lead to the alteration or loss of critical habitats for fish and other aquatic animals. Dams and channelization, in particular, can disrupt natural flow patterns and fragment habitats.

Aquatic Pollution: Pollution from various sources, including industrial discharges, agricultural runoff, and untreated sewage, can contaminate this river water. This pollution has detrimental effects on fish and other aquatic life. It could lead to reduced oxygen levels, altered water chemistry, and the accumulation of toxins.

Overfishing: Overfishing is a serious concern in Kuwano River ecosystems. Excessive harvesting of fish populations may lead to declines in target species and disrupt the balance of the ecosystem. It also impacts the livelihoods of local communities dependent on fishing.

Exotic Species: Invasive species, often introduced by human activities, can outcompete and displace native fish species. This competition can lead to a decrease in native biodiversity and alter the ecosystem's structure.

Climate Change: Climate change is altering water temperatures, flow patterns, and the timing of critical life events for fish. These changes can disrupt breeding and migration patterns and affect fish populations' ability to thrive.

Fisheries Management for Kuwano River Ecosystems: Protecting and restoring critical fish habitats is a fundamental aspect of fisheries management. This could include efforts to preserve riparian zones, reduce pollution, and mitigate the impacts of dams and other infrastructure. Establishing and enforcing regulations on fishing practices is essential to prevent overfishing and protect vulnerable fish populations. These regulations can include catch limits, size restrictions, and seasonal closures. Compliance with these rules is critical for sustainable fisheries management. Ongoing monitoring and research are essential to understand the health of river ecosystems and the status of fish populations. This information helps guide management decisions and adjust strategies as needed. Managing and controlling invasive species is vital to preserving native fish populations. This may involve the removal of invasive species or measures to prevent their introduction. Recognizing the impact of climate change on river ecosystems, fisheries management should include strategies to adapt to these changes. This could also involve altering regulations to account for shifting fish populations and changing habitat conditions. Local communities often rely on river ecosystems for their livelihoods. Involving these communities in decision-making processes, providing alternative livelihoods, and promoting sustainable fishing practices are essential elements of fisheries management. Effective fisheries management often requires collaboration between governments, conservation organizations, researchers, and local communities. Coordinated efforts can yield more successful outcomes in terms of conservation and sustainable fisheries.

Table 2: Systematic Checklist of fishes recorded from Kuwano River, their taxonomic position, common and vernacular names, Distribution along with IUCN Red List status, 2023

Sl. No.	Scientific Name	Vernacular Name	English Name	Distribution	IUCN Status	Current Population Status	Human Uses	Relative Abundance	Occurrences of fish in sampling sites		
									Site 1	Site 2	Site 3
Order: Cypriniformes Family: Cyprinidae (Minnows and Carps)											
1.	*Labeo catla* (Hamilton, 1822) [42] [42]	Bhakur, Katla	Catla	Pakistan, India, Bangladesh, Nepal and Myanmar	LC	Unknown	FF	Common	+	+	-
2.	*Labeo rohita* (Hamilton, 1822) [42]	Rohu	Rohu	Bangladesh; India; Myanmar; Nepal; Pakistan; Sri Lanka	LC	Unknown	FF	Common	+	+	-
	L. bata (Hamilton, 1822) [42]	Bata	Bata	Bangladesh; India; Myanmar	LC	Unknown	FF	Common	+	-	-
	L. gonius (Hamilton, 1822) [42]	Kuria, Kurai	Kuria labeo	Asia: Pakistan, India, Bangladesh, Myanmar, Afghanistan, Nepal	LC	Unknown	FF	Moderate	+	+	-
	L. calbasu (Hamilton, 1822) [42]	Karaunchi/ Karaunchh/ Karaunchar/ calbasu	Calbasu, Orangefin labeo	Bangladesh; China; India; Myanmar; Nepal; Pakistan; Thailand	LC	Unknown	FF	Common	+	+	+
	Cirrhinus mrigala (Hamilton, 1822) [42]	Nain/Naini	Mrigal	Pakistan, India, Nepal and Bangladesh	LC	Stable	FF	Common	+	+	-
	Cirrhinus reba (Hamilton, 1822) [42]	Raiya	Reba carp	Pakistan, India, Nepal, Bangladesh, and Myanmar	LC	Stable	FF	Common	-	+	+
	Ctenopharyngodon Idella (Valenciennes, 1884)*	Grass	Grass carp	Eastern China, Russia, India	LC	Unknown	FF	Common	-	+	-
	Hypophthalmichthys molitrix (Valenciennes, 1844)*	Silver fish	Silver carp	China, India, Bangladesh	NT	Decreasing	FF	Common	+	-	+
	Cyprinus carpio (Linnaeus, 1758)*	China rohu	Common carp	Afghanistan, China, India, Bangladesh	VU	Unknown	FF	Common	+	+	-
	Systomus sarana (Hamilton, 1822) [42]	Darahee	Olive barb, Peninsular olive barb	Bangladesh; India; Nepal; Pakistan	LC	Unknown	FF	Moderate	+	-	-
	Puntius sophore (Hamilton, 1822) [42]	Sidhari	Spotfin Swamp Barb	Bangladesh; China; India; Myanmar; Nepal; Pakistan; Thailand	LC	Unknown	FF, OF	Common	+	+	+
	Pethia ticto (Hamilton, 1822) [42]	Sidhari	Two spot barb, Ticto Barb	Bangladesh; India; Nepal; Pakistan; Sri Lanka	LC	Unknown	FF, OF	Common	+	+	-
	Pethia conchonius (Hamilton, 1822) [42]	Sidhari	Rosy barb	Afghanistan; Bangladesh; India; Nepal; Pakistan	LC	Unknown	FF, OF	Common	+	+	+
	P. chola (Hamilton, 1822) [42]	Sidhari	Chola Barb, Swamp barb	Pakistan, India, Nepal, Bangladesh, Sri Lanka and Myanmar, Bhutan	LC	Unknown	FF, OF	Common	+	+	+
	Osteobrama cotio (Hamilton, 1822) [42]	Gurda		Pakistan, India, Nepal and Bangladesh.	LC	Unknown	FF, OF	Common	+	+	+

Family: Danionidae											
	D. devario (Hamilton, 1822) [42]		Sind danio	Pakistan, India, Nepal and Bangladesh	LC	Unknown	FF, OF	Very common	+	+	-
	Esomus danrica (Hamilton, 1822) [42]	Dendua	Indian flying barb	Bangladesh; India; Myanmar; Nepal; Pakistan; Sri Lanka	LC	Stable	FF, OF	Very common	+	+	-
	Amblypharyngodon mola (Hamilton, 1822) [42]	Moa/ Dhawai	Mola carplet	Bangladesh; India, Pakistan, Myanmar, Afghanistan	LC	Stable	FF, OF	Very common	+	+	+
	Aspidoparia morar (Hamilton, 1822) [42]		Morar, Morari, Moraki	Iran, Afghanistan, Pakistan, India, Nepal, Bangladesh, Myanmar and Thailand	LC	Unknown	FF,OF	Very common	+	+	+
	Laubuka laubuca (Hamilton, 1822) [42]		Indian glass barb	Pakistan, India, Bangladesh, Sri Lanka, Myanmar, Malay Peninsula and Indonesia	LC	Unknown	FF,OF	Common	+	-	-
	Salmostoma bacaila (Hamilton, 1822) [42]	Chilwa	Large razorbelly minnow	Pakistan, India, Bangladesh, Nepal, Afghanistan	LC	Stable	FF	Very common	+	+	+
Family: Cobitidae (Spined loaches)											
	Lepidocephalichthys guntea (Hamilton, 1822) [42]	Naun fish	Guntea loach	Pakistan, northern India, Bangladesh, Nepal, Myanmar and Thailand	LC	Stable	FF, OF	Common	+	-	-
Family: Botiidae (Pointface loaches)											
	Botia lohachata (Chaudhuri, 1912)		Reticulate loach	Pakistan, India, Bangladesh and Nepal	LC		FF, OR	Common	+	-	-
Family: Nemacheilidae (Brook loaches)											
	Paracanthocobitis botia (Hamilton 1822)		Mottled loach	Pakistan, India, Bhutan, Nepal, Bangladesh, Myanmar, Thailand, Yunnan, China	LC		FF, OR	Common	+	+	+
Order: Siluriformes **Family: Siluroidae**											
	Wallago attu (Bloch et Schneider, 1801)	Padhani/ Pardni	Freshwater Shark	Bangladesh; Cambodia; India; Indonesia; Lao People's Democratic Republic; Myanmar; Nepal; Pakistan; Sri Lanka; Thailand; Viet Nam	VU	Decreasing	FF	Common	+	-	+
	Ompok bimaculatus (Bloch, 1794)	Jalkapoor	Butter catfish	Indian subcontinent and Myanmar	NE	Unknown	FF	Common	+	+	-
	O. pabda (Hamilton, 1822) [42]	Pabda	Pabdah catfish	Afghanistan, Pakistan, India, Bangladesh and Myanmar	NE	Decreasing	FF	Common	+	+	-
Family: Bagridae (Bagrid catfishes)											
	Mystus tengara (Hamilton, 1822) [42]	Tengara	Tengara catfish	Pakistan, India, Nepal and Bangladesh	LC	Unknown	FF,OF	Very common	+	+	+
	M. vittatus (Bloch, 1794)	Tengana	Striped dwarf catfish	Indian subcontinent, including Pakistan, India, Sri Lanka, Nepal, Bangladesh and probably Myanmar.	LC	Decreasing	FF,OF	Very common	+	+	+
	M. cavasius (Hamilton, 1822) [42]	Sutahawa tengra, Dariai	Gangetic mystus	Pakistan, Nepal, India, Sri Lanka and Myanmar	LC	Decreasing	FF,OF	Very common	+	+	+
	S. seenghala (Sykes, 1839)	Dariai Tengar	Giant river-catfish	Afghanistan, Pakistan, India, Nepal and Bangladesh, Thailand, China	LC	Unknown	FF	Very common	+	-	+
Family: Sisoridae (Sisorid catfishes)											
	Bagarius bagarius (Hamilton, 1822) [42]	Gonch	Goonch	Restricted to the Indian subcontinent and Bangladesh; Bhutan; India; Nepal; Pakistan	VU	Decreasing	FF, OF	Rare	+	-	+
Family: Heteropneustidae (Airsac catfishes)											
	Heteropneustes fossilis (Bloch, 1794)	Singhi	Singee, Stinging catfish	Bangladesh; India, Lao People's Democratic Republic; Myanmar; Nepal; Pakistan; Sri Lanka; Thailand	LC	Stable	FF, OF	Common	+	+	+

Family: Claridae (Airbreathing catfishes)											
	Clarias magur (Hamilton, 1822) [42]	Mangur, Deshi magur	Walking catfish	India and Bangladesh	EN	Decreasing	FF	Moderate	+	+	-
	C. gariepinus (Burchell, 1822)*	Bidesi magur	Thai mangur, North African catfish, African Catfish		LC	Unknown	FF	Moderate	-	+	-
Order: Perciformes **Family: Channidae (Snake headed fish)**											
	Channa marulius (Hamilton, 1822) [42]	Souri, Saur, Saul	Great snakehead	Asia: India to China, south to Thailand, Cambodia and Pakistan	LC	Unknown	FF, OF	Very Common	+	+	-
	C. punctata (Bloch, 1793)	Girohi/ Girai	Spotted snakehead	Afghanistan, Pakistan, India, Sri Lanka, Nepal, Bangladesh, Myanmar and China	LC	Stable	FF, OF	Very Common	+	+	+
	C. striata (Bloch, 1793)	Souri	Snakehead Murrel	Bangladesh; Cambodia; China; India; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; Nepal; Pakistan; Thailand; Viet Nam	LC	Stable	FF, OF	Very Common	+	+	+
	C. gachua (Hamilton, 1822) [42]	Chanaga, Chiranga	Dwarf Snakehead	Afghanistan; Bangladesh; Bhutan; Cambodia; China; Hong Kong; India; Indonesia, Malaysia; Myanmar; Nepal; Singapore; Sri Lanka; Thailand	LC	Unknown	FF, OF	Rare	+	+	-
Family: Ambassidae (Asiatic glassfishes)											
	Chanda nama (Hamilton, 1822) [42]	Chanari	Elongate Glass Perchlet	Pakistan, India, Nepal, Bangladesh, and Myanmar	LC	Decreasing	FF, OF	Very Common	+	+	+
	Parambassis ranga (Hamilton, 1822) [42]		Indian Glassy Fish, Indian Glass Perch	Bangladesh; Cambodia; India; Myanmar, Nepal; Pakistan	LC	Stable	FF, OF	Very Common	+	+	+
Order: Anabantiformes **Family: Anabantidae (Climbing gouramies)**											
	Anabas testudineus (Bloch, 1792)	Kawai	Climbing perch	India, Bangladesh, China, Malaysia; Myanmar; Nepal; Pakistan; Singapore; Sri Lanka; Thailand; Viet Nam	LC	Stable	FF, OF	Very Common	+	-	-
Family: Cichlidae											
	Oreochromis niloticus (Linnaeus, 1758)*	Jalebi	Nile tilapia	India, Bangladesh, Sri Lanka	LC	Unknown	FF, OF	Common	+	+	+
Family: Badidae (Chameleon fishes)											
	Badis badis (Hamilton, 1822) [42]	Sumha	Badis	Bangladesh; Bhutan; India, Nepal; Pakistan	LC	Unknown	FF, OF	Rare	+	-	+
Family: Nandidae (Asian leaffishes)											
	Nandus nandus (Hamilton, 1822) [42]		Gangetic leaffish	India, Bangladesh, Pakistan to Thailand.	LC	Unknown	FF, OF	Very Common	+	+	+
Family: Osphronemidae (Gouramies)											
	Trichogaster fasciata (Bloch & Schneider, 1801)	Khosti, Khesua	Banded gourami	Pakistan, India, Nepal, Bangladesh and upper Myanmar	LC	Unknown	FF, OF	Very Common	+	-	+
	T. lalius (Hamilton, 1822) [42]	Khosti, Khesua	Dwarf gourami	Pakistan, India, Bangladesh	LC	Unknown	FF, OF	Moderate	+	+	-
Order: Synbranchiformes **Family: Mastacembelidae (Spiny eels)**											
	Macrognathus pancalus (Hamilton, 1822) [42]	Bam/ Malga	Barred spiny eel/ Indian spiny eel	Bangladesh; India, Nepal; Pakistan	LC	Unknown	FF, OF	Common	+	+	+
	Mastacembelus armatus (Lacepède, 1800)	Bam	Zig-zag eel	Bangladesh; India, Nepal; Pakistan	LC	Stable	FF, OF	Common	+	+	+
	M. aculeatus (Bloch, 1786)		Lesser spiny eel	Indonesia; Malaysia, India, Bangladesh	LC	Unknown	FF, OF	Moderate	+	+	+
Family: Synbranchidae (Swamp-eels)											
	Ophichthys cuchia (Hamilton, 1822) [42]	Andhasanp/Cuchia/ Andhawa	Cuchia, Gangetic mudeel, Mud eel, Rice eel, Swamp eel	Pakistan, India, Nepal, Bangladesh, Myanmar	LC	Unknown	FF, OF	Very Common	+	+	+

Order: Osteoglossiformes (Bony tongues) Family: Notopteridae (Featherbacks or knifefishes)											
	Chitala chitala (Hamilton, 1822) [42]	Moya/ Moi	Clown knifefish	Bangladesh; India, Nepal; Pakistan	NT	Decreasing	FF, OF	Rare	+	-	-
	Notopterus notopterus (Pallas, 1769)	Patra	Bronze featherback	Bangladesh; Cambodia; India; Indonesia Malaysia Myanmar, Nepal; Pakistan; Thailand; Viet Nam	LC	Stable	FF,OF	Common	+	+	+
Order: Gobiiformes Family: Gobioidae (Gobies)											
	Glossogobius giuris (Hamilton, 1822) [42]	Bulla	Bareye Goby, Bar Eyed Goby, Bar-eyed Goby, Flat-headed Goby, Flathead Goby, Forktongue Goby, Fresh Water Goby, Gangetic Tank Goby, Tank Goby, White goby	Bangladesh; China; India; Indonesia; Malaysia; Myanmar; Nepal; Pakistan; Singapore; Sri Lanka	LC	Unknown	FF, OF	Common	+	+	+
Order: Beloniformes Family: Belonidae (Needlefishes)											
	Xenentodon cancila (Hamilton, 1822) [42]	Kawwa machli/ Kauwa	Freshwater garfish	Bangladesh; Bhutan; India Myanmar; Nepal; Pakistan; Thailand	LC	Unknown	FF, OF	Very common	+	+	+
Note: NE: Not Evaluated; EN: Endangered; NT: Near threatened; LC: Least Concern; CR: Critically endangered; DD: Data Deficient; VU: Vulnerable: FF: Food fish: OF: Ornamental fish; '+': indicate the presence of species; '-': indicate absence of species; *: Exotic fishes.											
Source of information: Fish base (https://www.fishbase.se/search.php); IUCN Red list (https://www.iucnredlist.org/); WORM (https://www.marinespecies.org/index.php); Eschmeyer's Catalog of Fishes											

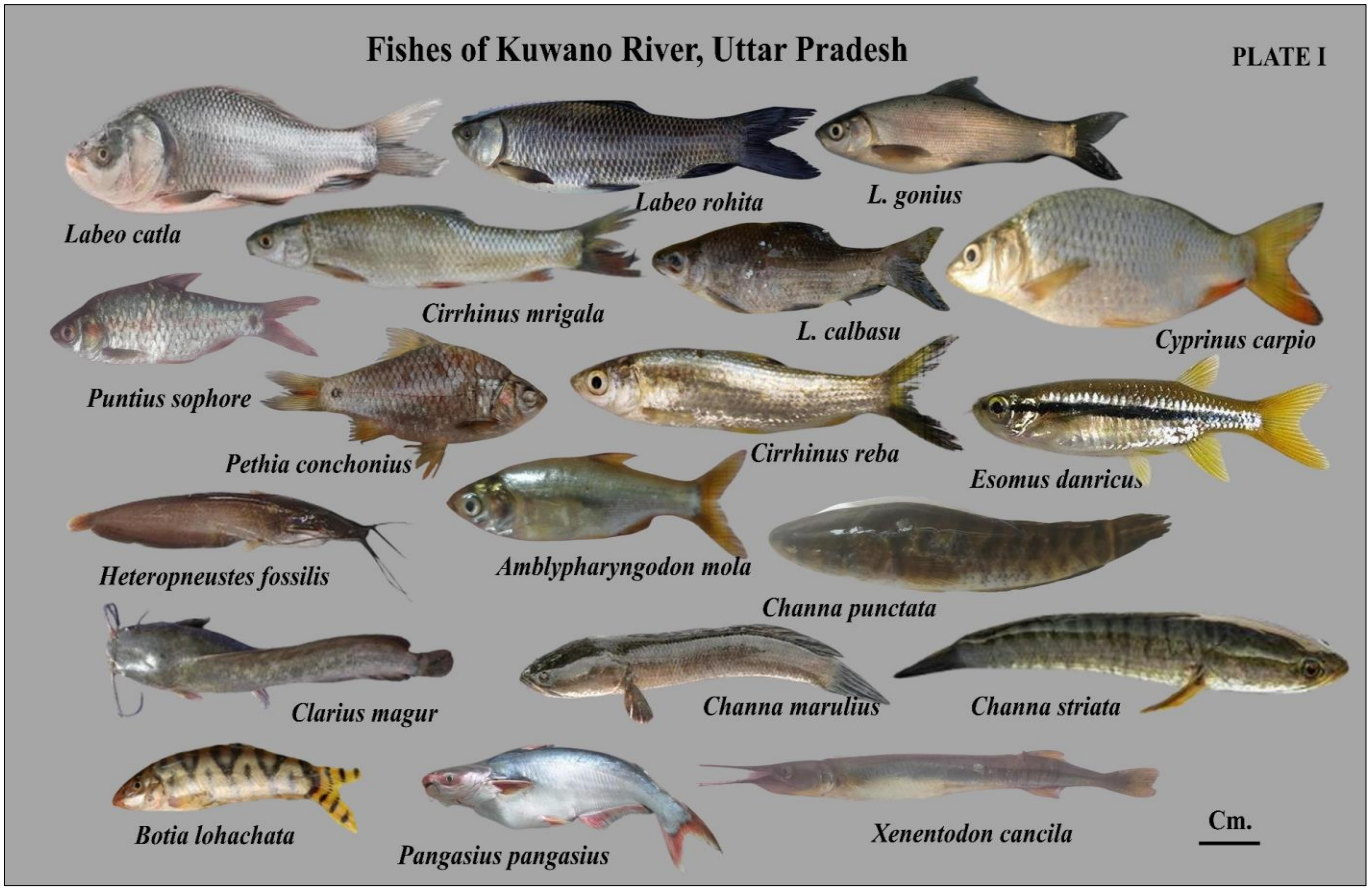

Plate 1: Fish species recorded from the Kuwano River, UP

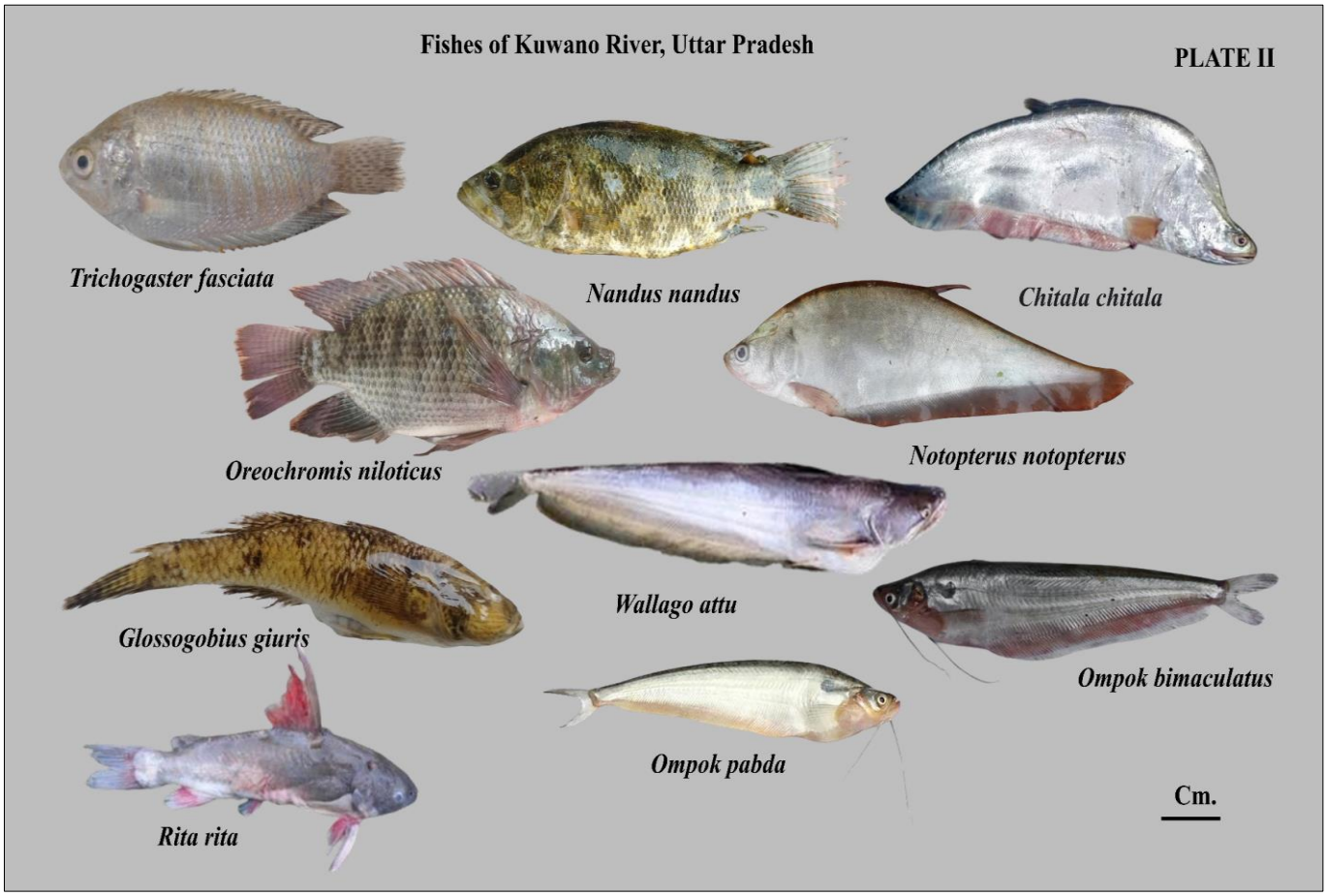

Plate 2: Fish species recorded from the Kuwano River, UP

Conclusion

In conclusion, this study provides the first basic and baseline information on ichthyofauna diversity in the Kuwano River that would be benificial for fishery biologists and conservationists to impose adequate regulations for sustainable fishery management and conservation of diversity for the river as well as for other small rivers in Uttar Pradesh.

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References

1. Bano F, Serajuddin M. Biodiversity, Threat Status and Conservation Priority of Icthyo-fauna of River Gomti at Lucknow Region, India. Biodiversity Journal. 2016;7(4):913-922.
2. Cooke SJ, Hogan ZS, Butcher PA, Stokesbury MJ, Raghavan R, Gallagher AJ, *et al*. Angling for endangered fish: conservation problem or conservation action? Fish and Fisheries. 2016;17(1):249-265.
3. Das SCS, Khan A, Alam A, Dubey VK, Joshi KD. January). Piscine diversity, Community structure and Distribution patterns of the West Ramganga River: A mid-Himalayan tributary of River Ganga. ICAR; c2020.
4. Day F. Fishes: Fauna of British India Including Ceylon and Burma. Today & Tomorrow Printers & Publishers; c1989.
5. Pratap Chandran R, Anusha Vijayan S, Silpa S, Sruthy P and Sreelekshmi S. Isolation of pathogens from leaf, root and rhizosphere water samples of aquatic weeds, *Eichhornia crassipes* and *Pistia stratiotes* present in the backwaters of YMCA canal, Alappuzha, Kerala, India. Int. J. Biol. Sci. 2021;3(2):24-29. DOI: 10.33545/26649926.2021.v3.i2a.131
6. Gupta D, Tripathi M. Present status and diversity of ichthyofauna at five selected sites of the Gomti River, Lucknow (India). International Journal of Fauna and Biological studies. 2017;4(1):49-56.
7. Heda NK. Fish diversity studies of two rivers of the northeastern Godavari basin, India. Journal of Threatened Taxa; c2009. p. 514-518.
8. Jayaram KC. The freshwater fishes of the Indian region. New Delhi: Narendra Publishing House, 1999, 551.
9. Jitendra K, Pandey AK, Dwivedi AC, Naik ASK, Maliesh V, Benakappa S. Ichthyofaunal diversity of district Faizabad (Uttar Pradesh), India. Journal of Experimental Zoology, India. 2013;16(1):149-154.
10. Jitendra K, Pandey AK, Dwivedi AC, Naik ASK, Maliesh V, Benakappa S. Ichthyofaunal diversity of district Faizabad (Uttar Pradesh), India. Journal of Experimental Zoology, India. 2013;16(1):149-154.
11. Kumar D, Maurya AK, Prasad L, Singh CP, Radhakrishnan KV, Somasekara SR. Fish biodiversity and its diversity indices in the Himalayan River Ghaghara at Northern India; c2020.
12. Lakra WS, Sarkar UK, Gopalakrishnan A, Pandian AK. Threatened freshwater fishes of India. NBFGR, Publ; c2010b. ISBN: 978-81-905540-5-3.
13. Lakra WS. Fish biodiversity of Uttar Pradesh: issues of livelihood security, threats and conservation, in National Conference on Biodiversity, Development and Poverty Alleviation. Uttar Pradesh State Biodiversity Board,

India; c2010. p. 40-45.
14. Lowe S, Browne M, Boudjelas S, De Poorter M. 100 of the world's worst invasive alien species: a selection from the global invasive species database (Vol. 12). Auckland: Invasive Species Specialist Group; c2000.
15. Mishra SK, Sarkar UK, Gupta BK, Trivedi SP, Dubey VK, Pal A. Pattern of freshwater fish diversity, threats and issues of fisheries management in an unexplored tributary of the Ganges basin; c2011.
16. Molur S, Smith KG, Daniel BA, Darwall WRT. (Compilers). The Status and Distribution of Freshwater Biodiversity in the Western Ghats, India. Cambridge, UK and Gland, Switzerland: IUCN, and Coimbatore, India: Zoo Outreach Organisation; c2011.
17. Pandey KC, Agrawal N, Sharma RK. Fish fauna of Surha Tal of District-Ballia (UP), India. Journal of Applied and Natural Science. 2010;2(1):22-25.
18. Pathak AK. Empirical assessment of fish diversity of Uttar Pradesh, India: Current status, implications and strategies for management. International Journal of Fisheries Science and Research. 2018;2(1):1005-1011.
19. Pathak AK, Sarkar UK, Abidi R. Status of fish diversity in Surha Taal, a natural lake in the floodplains of river Ganga, in Ballia District, Uttar Pradesh, India. Indian Journal of Fisheries. 2020;67(3):157-163.
20. Paunikar SD. Species diversity, population structure and conservation status of fishes inhabiting in six different wetlands of Uttar Pradesh; c2021. https://doi.org/10.22271/fish.2021.v9.i5a.2561.
21. Radhakrishnan KV, Kurup BM. Ichthyodiversity of Periyar Tiger Reserve, Kerala, India. Journal of Threatened Taxa. 2010;2(10):1192-1198.
22. Sahu S, Pramila S. Diversity of molluscs in the middle stretch of Ganga river (Kanpur to Allahabad), Uttar Pradesh. MFSc Thesis. Kerala University of Fisheries and Ocean Studies, Kerala; c2021.
23. Sandilyan S. Occurrence of ornamental fishes: a looming danger for inland fish diversity of India. Current Science; c2016. p. 2099-2104.
24. Sarkar UK, Bain MB. Priority habitats for the conservation of large river fishes in the Ganges River basin. Aquat Conserv Mar Freshw Ecosyt. 2007;17:349-359.
25. Sarkar UK, Deepak PK, Negi RS. Age structure of Indian carp Labeo rohita (Hamilton Buchanan) from different wild population. Environ Ecol. 2006;24(4):803-808.
26. Sarkar UK, Gupta BK, Lakra WS. Biodiversity, ecohydrology, threat status and conservation priority of the freshwater fishes of river Gomti, a tributary of river Ganga (India). Environmentalist. 2010;30(1):3-17.
27. Sarkar UK, Pathak AK, Sinha RK, Sivakumar K, Pandian AK, Pandey A, *et al*. Freshwater fish biodiversity in the River Ganga (India): changing pattern, threats and conservation perspectives. Reviews in Fish Biology and Fisheries. 2012;22:251-272.
28. Sarkar UK, Pathak AK, Lakra WS, *et al*. Conservation of freshwater fish resources of India: new approaches, assessment and challenges. Biodiversity Conservation. 2008;17:2495-2511.
29. Sarkar UK, Pathak AK, Paul SK, Deepak PK, Tyagi LK. Status of fish diversity in Katerniaghat Wildlife Sanctuary, India and its role in conservation of endangered freshwater fish of the Terai region. J. Bombay Natural History Society. 2007;104:35-42.
30. Serajuddin M, Ali R, Faridi AA. Freshwater fish diversity of Santravidas Nagar, Bhadohi District of Eastern Uttar Pradesh, India. J. Natural Conserv. 2004;16:413-422.
31. Dudgeon D, editor. Tropical stream ecology. Elsevier; 2011 May 4.
32. Sahu S, Medina-Carrillo B, Sánchez-Colón G, Rajpoot S. Deciphering the~ 18 TeV Photons from GRB 221009A. The Astrophysical Journal Letters. 2023 Jan 11;942(2):L30.
33. Dudgeon D, Arthington AH, Gessner MO, Kawabata ZI, Knowler DJ, Lévêque C, *et al*. Freshwater biodiversity: importance, threats, status and conservation challenges. Biological reviews. 2006 May;81(2):163-182.
34. Revenga C, Murray S, Abramovitz J, Hammond A. Watersheds of the world: ecological value and vulnerability. World Resources Institute; c1998.
35. Kushwaha AK, Kumar P, Kar AK. What impacts customer experience for B2B enterprises on using AI-enabled chatbots? Insights from Big data analytics. Industrial Marketing Management. 2021 Oct 1;98:207-221.
36. Day SP. Tea, Its Mystery and History. Simpkin, Marshall & Company; 1878.
37. Talwar PK, Jhingran AG. Inland fishes of India and adjacent countries. CRC press; 1991 Jun 1.
38. Kottelat M. Freshwater fishes of Northern Vietnam: a preliminary check-list of the fishes known or expected to occur in northern Vietnam with comments on systematics and nomenclature. (No Title); c2001.
39. Gopal-Srivastava R, Kays WT, Piatigorsky J. Enhancer-independent promoter activity of the mouse αB-crystallin/small heat shock protein gene in the lens and cornea of transgenic mice. Mechanisms of development. 2000 Apr 1;92(2):125-134.
40. Clarke KR, Warwick RM. A further biodiversity index applicable to species lists: variation in taxonomic distinctness. Marine ecology Progress series. 2001 Jul 6;216:265-278.
41. Clarke KR, Gorley RN. Primer. PRIMER-e, Plymouth; c2006. p. 866.
42. Hamilton F. An account of the fishes found in the river Ganges and its branches. Constable; c1822.
43. Ghosh SK, Ponniah AG. Freshwater fish habitat science and management in India. Aquatic Ecosystem Health & Management. 2008;11(3):272-288.