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Biodiversity: The Non-natives Species Versus the Natives Species and Ecosystem Functioning

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Abstract

The loss of biodiversity is one of the most reflective effects of humans on the global perspective and it is more and more urgent to understand how this loss will affect and what will be the profound consequences to the ecosystem functioning. Non-native fishes can cause considerable adverse impacts on the function of aquatic ecosystems and loss of biodiversity. Ecology of ecosystem focuses on the fluctuation of energy and nutrients through ecological systems. It has been confirmed that the fishes are sensitive indicators of environmental degradation and alteration. Study was undertaken during the period of October 2015 to September 2016 from the Paisuni river, India. Fish faunas of the Paisuni river have harbors of 58 species belonging to 5 order, 18 family and 43 genera. Cypriniformes and Cyprinidae were the most rich fish species order and families, respectively from the river. The Cyprinidae family has highest harbors family with 25 fish species. The family Anabaniitidae has 5 fish species which is second dominant family from the Paisuni river. According to abundance, *Cyprinus carpio* and *Oreochromis niloticus* were powerfully invaded in the Paisuni river. The detonated frequency of *O. niloticus* and *C. carpio* was recorded from the Paisuni river. Exotic species is alarming for indigenous fish species biodiversity. *C. carpio* and *O. niloticus* are frequently recorded in the Ganga river. Very highly important and ecological indicator fish species, Tor mahseer, Tor tor is declining in the catch. Current ecosystem functioning is favour to non-native species from the Paisuni river.

Keywords: Biodiversity; Tor mahseer; Non-native; Ganga basin; Ecosystem function

Introduction

Indian faunas and floras have a well-known set in maintaining global biodiversity and food security. The native fish stock management and non-native fish impact evaluation in respect of ecosystem function and biodiversity, currently disputing both scientific communities and environmental executives (e.g. policy maker/government) especially in developing countries. Biodiversity is necessary for stabilization of ecosystem, protection of overall environmental quality for understanding intrinsic value of all species on the Earth [1-3]. Biodiversity affects the capacity of living systems to respond to changes in the environment, underpins ecosystem function and provides the ecosystem goods and services that support human well-being [4-7]. Human activities play a robust responsibility in contrast with other natural process in changing the biodiversity and invasions of species [8,9]. The loss of biological diversity is one of the most profound effects of humans on the global environment [10,11]. Non-native species threaten biodiversity from local to global [11-13] and also treated the function of ecosystems globally [14-16]. Invasion of non-native species in freshwater ecosystem (e.g. rivers, reservoirs, wetlands) are first of all threatened commercial fishes with alteration of ecosystem function. As a consequence to the failure of the natural functions of the ecosystem. Non-native species may become invasive and are capable of spreading exotic diseases, decreasing biodiversity through competition, predation and habitat degradation, genetic deterioration of wild populations through hybridization and gene introgression in short or long course of time [17,18].

Freshwater ecosystems might be the most endangered ecosystems in the globe [19] and highly vulnerable [20]. The term "ecosystem functioning" refers to all processing and transport of energy and matter in an ecosystem, incorporating numerous individual functioning performed in the ecosystems. The communities of organisms are dependent on each other and to their environment live in aquatic ecosystems. Strong ecosystem functions are benefited to the people and other organisms, both direct and indirect by ecosystem and biodiversity. Classically, ecosystem function in respect of biodiversity (e.g. as a natural resource) has been expected undervalued and underpriced in developing countries, owing to the fulfillment and underpin to their luxurious need by the peoples and the government of these countries. The water pollution, flow modification, degradation of habitat, eutrophication, overexploitation of resources and fishes and invasion of non-native species are major foundations which transform the ecosystem functioning [21-25].

Managing of fish diversity is one of our biggest globally challenges due to invasions of exotic species, need of malnutrition, fishing pressure, pollution and alteration of river. Freshwater biodiversity are important and prized property for broad variety of valuable goods, human food, income, sport and ornament [26]. Introductions of non-native species are known to modify the similarity in species structure [27-29]. The global biodiversity threaten concerns not simply recorded loss of species within stock, but also connected significantly to ecosystem function, nature of food web and food security [30,31]. Humans rely on healthy freshwater ecosystems for the benefits and services they provide [30,32]. The fish faunas are homogenized by few non-native species, globally [33-37]. Illegal fishing using dynamite, pesticides, electrofishing are also major threats to fish biodiversity all over the world [38-40]. Consistently, a variety of outlooks exist among faunas (e.g. fish biodiversity) and ecosystem function on what the deployed

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desired level of environmental condition should be and the trade-offs that are ample in improving human well-being. The objective of the present study was to give a fish biodiversity with the correlation of non-native species and ecosystem functioning from the Paisuni river, India.

Material and Methods

Study area

The Paisuni river was selected for the herein study. It is a religious river for Indian people. The river drains the Bundelkhand geographic region of central India. Bundelkhand lies between the Indo-Gangetic Plain to the north and the Vindhya Range to the south. The latter is a range of hills in central India. The western end of the range rises in eastern Gujarat state, near the border with Madhya Pradesh, and the range runs east and north nearly to the Ganges River at Mirzapur. They form a dividing ridge between the Hindustan proper and the Deccan. The Vindhyan Mountains are older than the Himalaya and Satpura. They are a vast stratified formation of sand stones, shales and limestones encompassing a thickness of over 4270 m. The Vindhyan scar land has an elevation between 450 to 650 m above msl [41,42]. The Bundelkhand is a gently-sloping upland, distinguished by barren hilly terrain with sparse vegetation, although it was historically forested. The plains of Bundelkhand are intersected by three mountain ranges, including the Vindhya chain, the highest elevation not exceeding 600 meters above sea-level.

About Paisuni river

The Paisuni river is fundamentally a hill stream arising in the hills of the south Pathar Kachar near Majhgawan. It is a perennial river and has medium flow. The river lies between latitude 25º 08' 14" to 25º 16' 17" N and longitude 80º 51' 01" to 80º 50' 28" East. It falls in two fine cascades separated by deep pools filled with clear and translucent waters. The Paisuni flows through the deep gorges of sand scrapments. Banks are steeplike, the bed is rocky upstream. It meets with the Yamuna river at Rajapur. Upstream of Chitrakoot the headwaters of the river flow through forest while downstream of Karwi agriculture were prevalent. The stony substrate occurred from upper and middle stretch while silt-clay-sand at lower stretch [42]. Water levels are found lowest during May-June and highest during July to September, when a 3-5 meter rise in water level forms a broad channel of the River.

The fish samples and related information were collected monthly from October 2015 to September 2016 from the Paisuni river, India. The collected samples were preserved in 10% formalin and brought to the laboratory for further study. The fish was identified by using [43-45] books and standard keys. The meristic and morphometric characters of collected fishes were measured and counted; fishes were identified up to the species level.

Result and Discussion

Riverine ecosystem is highly vulnerable to stressors such as species invasion, ecological niches, eutrophication, industrial influents, land-use change, food web and changes in biodiversity. Each natural habitat has a variety of species, which differ in their relative abundance and richness. No community consists of species of equal abundance. Some species are rare, others are common and still others may be abundant. 58 fish species were recorded with 5 orders, 18 families and 43 genera from the Paisuni river. Cypriniformes order was shared 27 species (46.55%) followed by Siluriformes 14 species (24.14%) and Perciformes 13 species (22.41%). Order Osteoglossiformes and Clupeiformes shared 2 species each (Table 1). Twenty five fish species belonging to Cyprinidae family. The family Anabaniitidae has 5 fish species which is second dominant family from the Paisuni river (Figure 1). Biodiversity is the beneficial to human being through direct and indirect. [46] has stated that the high diversity is a buffer, against environmental fluxes, because different species react differently to these fluxes, leading to more predictable aggregate community or ecosystem properties. Indian major carps (Catla catla, Labeo rohita, Cirrhinus mrigala) and Tor mahseer (*Tor tor*) are belonging to Cypriniformes order. These fishes stock was dramatically declined from the Paisuni river. The total length of these fishes was found to be reduced. Indian major carps were the backbone of capture fisheries in India in 20th century but nowadays these fishes are being the backbone of culture fishery. In general for this region in respect of aquaculture, *C. carpio* and *O. niloticus* has to be high generating adequate profit, increasing risk of harmful impacts on the aquatic system. The nonstop impacts of these introduced fishes in natural ecosystems (e.g. rivers, reservoirs, wetlands, lakes) are very robust and extirpated such as stock reduction and even local extinctions of indigenous species [47-49]. *C. catla*, *L. rohita*, *C. mrigala* and *T. tor* are functionally important fish species from the Paisuni river, India. These fishes are herbivorous in nature. The phytoplanktons and aquatic plants are serving as primary producers and represent the basal component of aquatic ecosystems; they have been represented the functional unit and provide a platform for richness of fish biodiversity.

Due to invasion of non-native fish species, *C. carpio* and *O. niloticus* in the riverine water system, there was a random decline has been found in the stock and abundance of Indian major carps from the Paisuni river and other rivers of the Ganga river basin, India [49-52]. Overall *C. carpio* was the most dominant fish species by virtue of the number. *O. niloticus* was the second most dominant fish species within higher and medium size groups (e.g. total length) from the Paisuni river. *C. mrigala* and *C. carpio* have similar feeding habits (e.g. bottom feeder). C. carpio has also overexploited the native trophic resources. Tor mahseer, T. tor stock was also reduced which is very important and highly economically important fish species for this region [53]. *C. carpio* (29.3%) and *O. niloticus* (9.27%) were frequently recorded in total landing from the Paisuni river, showing off significant threats to the natural environment and probably causing significant socio-economic consequences. Both species have large dispersal capacity in riverine ecosystem. Both species are exotic/alien fish species for India. Earlier report [48] was indicated that the Indian major carps have shared 15.08% of the total landing but in present study period it has been shared only 9.52%.

C. carpio and *O. niloticus* are first of all established in the Yamuna river, after few year these fishes has spread and established in the hole Ganga river basin. The established population of non-native species may carry on spreading in the surrounding areas [36]. The detonated frequency of *O. niloticus* and *C. carpio* was recorded from the Paisuni river. For conservation point of view *C. carpio* and *O. niloticus* species should be monitored in the Paisuni river. Both species are very harmful for fish biodiversity in any water bodies as like rivers, lakes and reservoirs. The Paisuni river is situated in the Ganga river basin. The basin has intensive agriculture and dense human settlement. Intensive agriculture and dense settlement of human being are showing high biodiversity threat [12,54-56].

The persecuted fish biodiversity of developing countries are in high predicament due to the predisposition of the management. The water bodies in these countries suffer from various stressors such as political pressure, invasion of exotic species, dam construction, overexploitation, unsystematic manner of fishing etc. (Figure 2). Non-native species have the potential to compensate for the loss of total landing of fishes.

S. N.	Order/Family/Genus/Species	S. N.	Order/Family/Genus/Species
	Order-Osteoglossiformes	33	*Sperata seenghala*
	Family: Notopteridae	34	*Mystus cavasius*
1	*Chitala chitala*	35	*Rita rita*
2	*Notopterus notopterus*		**Family: Siluridae**
	Order-Clupeiformes	36	*Ompok bimaculatus*
	Family: Clupeidae	37	*Wallago attu*
3	*Gudusia chapra*		**Family:Schilbeidae**
4	*Goniolosa manmina*	38	*Ailia coila*
	Order-Cypriniformes	39	*Clupisoma garua*
	Family: Cyprinidae	40	*Eutropiichthys vacha*
5	*Catla catla*		**Family: Sisoridae**
6	*Chagunius chagunio*	41	*Bagarius bagarius*
7	*Cirrhinus mrigala*	42	*Gagata cenia*
8	*Cirrhinus reba*		**Family:Clariidae**
9	*Cyprinus carpio*	43	*Clarias batrachus*
10	*Labeo calbasu*		**Family: Heteropneustidae**
11	*Labeo bata*	44	*Heteropneustes fossilis*
12	*Labeo fimbriatus*		**Family: Belonidae**
13	*Labeo rohita*	45	*Xenentodon cancila*
14	*Labeo gonius*		**Order-Perciformes**
15	*Osteobrama cotio cotio*		**Family: Ambassidae**
16	*Puntius chola*	46	*Chanda nama*
17	*Puntius conchonius*	47	*Pseudambassis ranga*
18	*Puntius sarana sarana*		**Familty: Sciaenidae**
19	*Puntius sophore*	48	*Johnius coitor*
20	*Puntius ticto*		**Family: Gobiidae**
21	*Chela laubuca*	49	*Glossogobius giuris*
22	*Salmostoma bacaila*		**Family: Anabaniitidae**
23	*Amblypharyngodon mola*	50	*Anabas testudineus*
24	*Aspidoparia jaya*	51	*Channa marulius*
25	*Aspidoparia morar*	52	*Channa punctatus*
26	*Barilius barila*	53	*Channa striatus*
27	*Barilius bendelisis*	54	*Rhinomugil corsula*
28	*Tor tor*		**Family: Mastacembelidae**
29	*Osteobrama cotio cotio*	55	*Macrognathus pancalus*
	Family: Cobitidae	56	*Mastacembelus armatus*
30	*Botia lohachata*		**Family: Nandidae**
31	*Botia dario*	57	*Nandus nandus*
	Order-Siluriformes		**Family: Cichlidae**
	Family: Bagridae	58	*Oreochromis niloticus*
32	*Sperata aor*		

Table 1: Biodiversity of fishes from the Paisuni river (Ganga river basin), India.

The abundance and density of *O. niloticus* and *C. carpio* from the Paisuni river were 100 times greater than the *C. catla*, *L. rohita* and *C. mrigala* (Indian major carps) and also 500 times greater in contrast to Tor mahseer (*T. tor*). *T. tor* is a rare fish species. The rare species are represented by only a little number of individuals and restricted to selected habitat (e.g. suitable habitat). The rare species may truly replace by dominant species subsequent disturbance, contributing to the continued existence of an ecosystem function in its preferred stable position [57]. The overexploitation of fishes have significant effects on ecosystem functioning. Individual species are most important for ecosystem functioning as are numerous species [58]. If non-native species are dominant in new ecosystem then the ecosystem functioning would be changed and the large sized fish stock might be disturbed within native stock. Few abundant species may be sufficient for bodacious effects to the degree of ecosystem functioning.

Due to feeding nature, *C. carpio* increase suspended solids (e.g. turbidity) via sediment resuspension in the Paisuni river. Sediment resuspension and excretion by *C. carpio* can boost the water column nutrient levels, leading to phytoplankton blooms [59]. Turbidity was recorded to be increased due to *C. carpio* in the water bodies [60-62], has recorded that *C. carpio* significantly increases turbidity and suspended solids in the water body. The discharge of water was also found to be decreased in the Paisuni river. The invasion of *C. carpio*, *O. niloticus* and discharge are the main factors which has been damaging the native stock of fishes. Due to poor water volume in the river, space and food are gradually shrunken. The discharge of water is directly proportional to the size of the fishes.

The abundance of large sized fishes in the Paisuni river in winter and summer seasons are very poor especially *C. catla*, *L. rohita*, *C. mrigala* and *T. tor*. These fishes in summer and winter seasons have used deep gorges of the river for shelter. The ecosystem of the Paisuni river are very supportive to the production of green algae and blue green algae

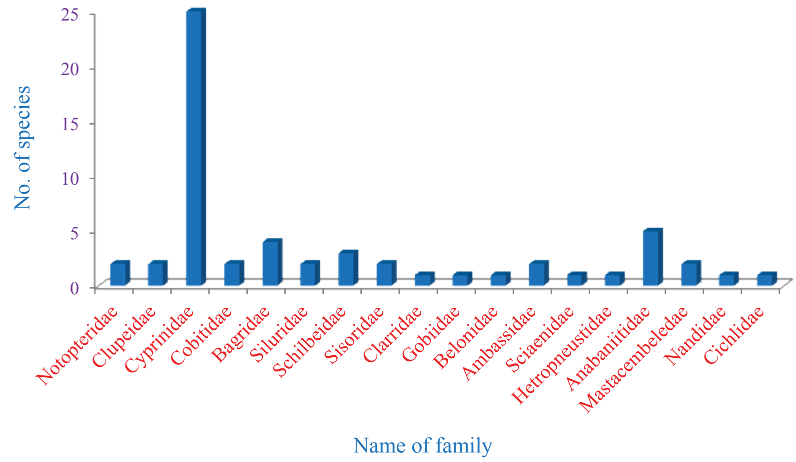

Figure 1: Structure and composition of fish species within family from the Paisuni river.

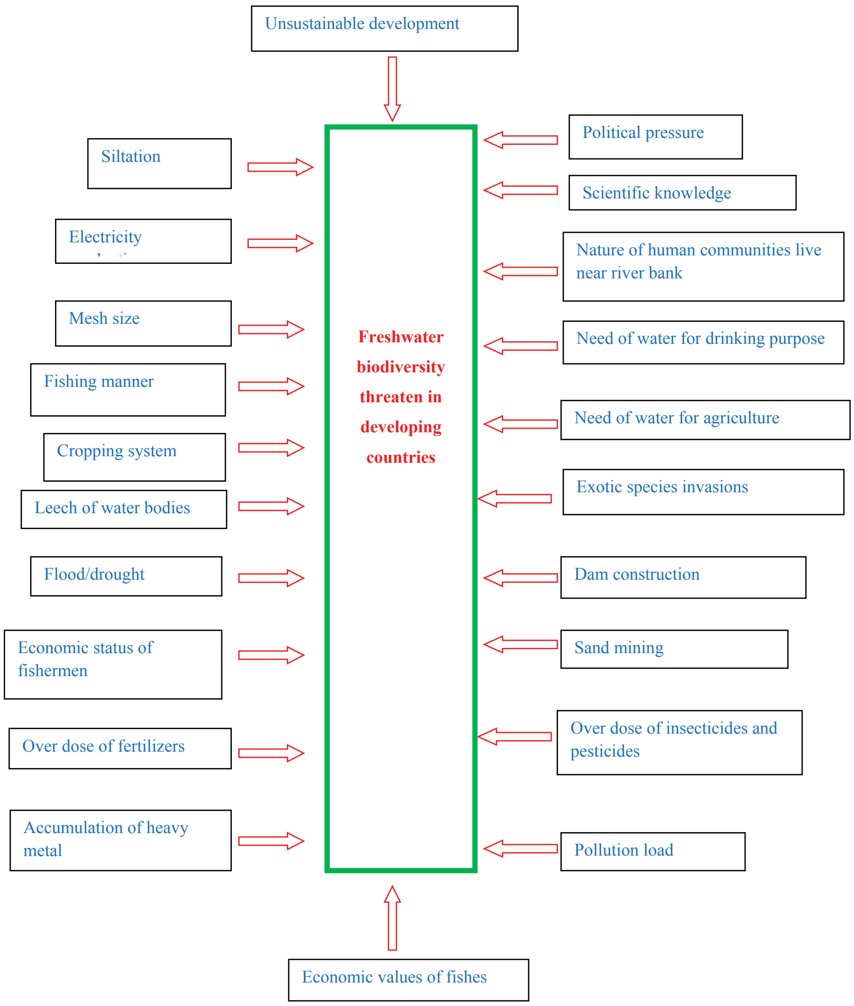

Figure 2: Simplified frameworks for threaten freshwater biodiversity in developing countries. The conceptual framework process runs by ecological condition, ecosystem function and services. Note that biodiversity loss by also local unsustainable development and human responsibility. The seasonal and climatic changes are also proportional to the biodiversity loss. Habitat change and loss is one of the most important derivers of the biodiversity loss. The water pollutant can have negative effects on biodiversity and ecosystem function.

and these algae are considered as the basic food of *C. catla*, *L. rohita*, *C. mrigala*, *T. tor*, *C. carpio* and *O. niloticus* in the Paisuni river. Due to the heavy competition for food and space with non-native species, the Indian major carps stock have been damaged in the Paisuni river and The length and stock of T. tor has been declined from the Paisuni river [63,64]. The eutrophication has also been considered as one of the major environmental problem from the Paisuni river after invasion of *C. carpio*. [65,66] has stated that the eutrophic water bodies has normally showing high abundances of zooplanktovorous fishes, thus it produces professional large-bodied grazers (e.g. Daphnia) and showing the way to huge algal production and growth, or so called blooms. The natural incident and human activities can affect ecosystem function through the biodiversity changes [67,68]. Ecosystem functioning has also been affected by altering the size composition in functional sets. These fishes have developed their own strategy to survive with the poor water quality [69-72].

The aquatic ecosystems before intrusion of non-native species are providing services completely in the form of interlinking of ecological fundamentals. After invasion of non-native species, in initial first few steps indigenous species are dominant and creating pressure to non-native species, but within 5 to 8 years, after successive adaptation and stability of stock, non-native species have created a pressure to indigenous species. Finally, when non-native species has been dominated over to indigenous species then it creates a pressure on all native species and threatens of biodiversity (Figure 3). The ecosystem

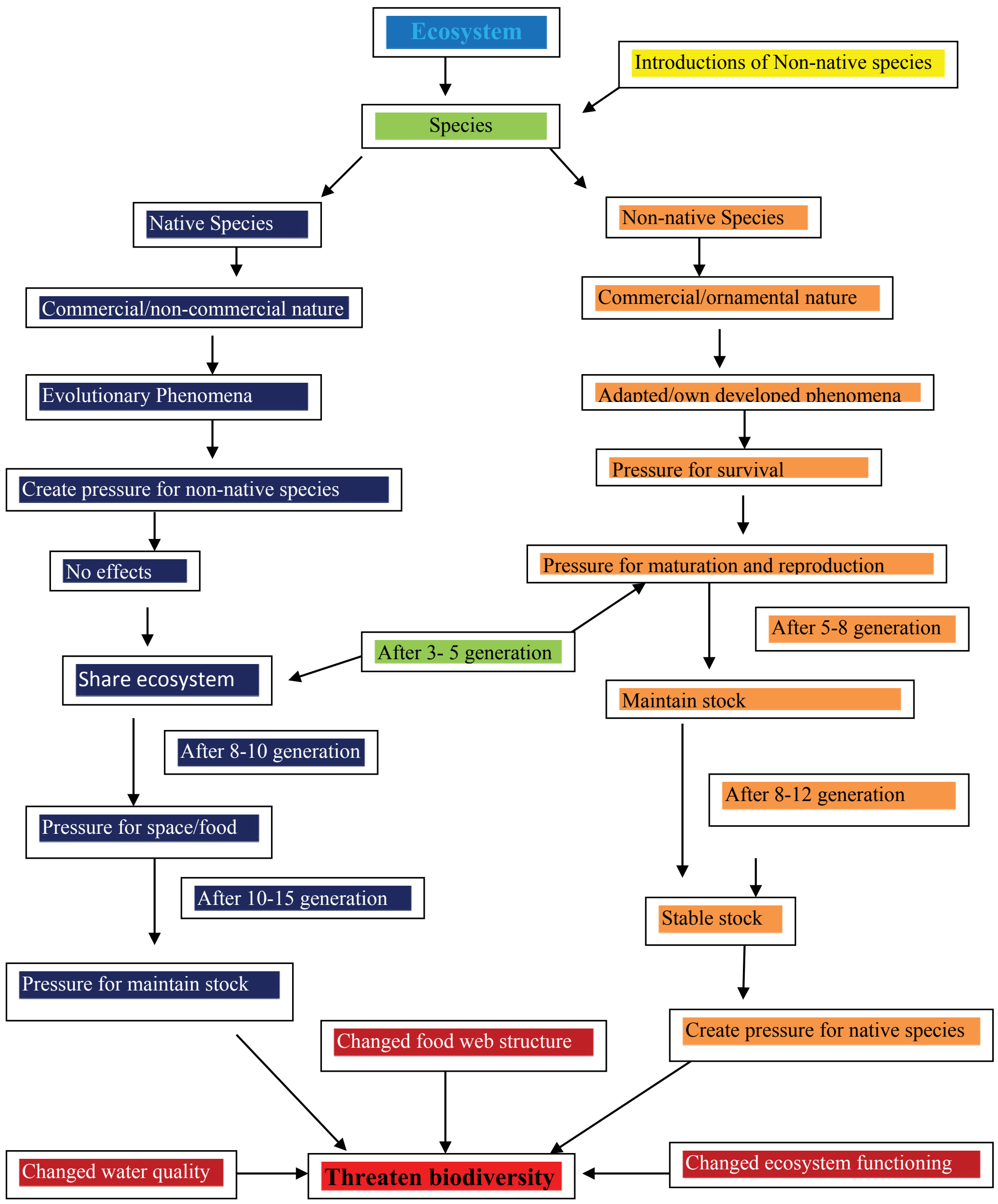

Figure 3: A schematic diagram of the threaten biodiversity from the ecosystem through native and non-native species. Freshwater biodiversity threaten by natural or human pathways. A spatial differentiation incident threat also occurs from the interaction of multiple dynamics.

of the Paisuni river is functioning according to need of *C. carpio* and *O. niloticus* or in other words it is highly supportive to both fishes. In a river ecosystem, each and every species have unique position, responsibility, role and function. When too many species of the aquatic system have been losted, after that the ecosystem would be changed and would function in its own specialized behavior with the relation of ecosystem and remaining organisms. Individual species are as important for ecosystem processes as are mélange of species [32,71]. *O. niloticus* has modifying trophic web structure through competing with other indigenous fish and preying on juveniles of fishes [73,74], has stated along with evidence that there is a direct relationship between biodiversity and ecosystem functioning. Native species are always supportive to stable the biodiversity of water bodies. Fishes are mainly threatened by channelization of rivers/streams beds, changes of food web and invasion of non-native species [25,75].

The more species are needed to insure a stable supply of ecosystem goods and services as spatial and temporal variability increases, which typically occurs as longer time periods and larger areas are considered [4]. Each natural habitat has a variety of species, which differ in their relative abundance. No community consists of species of equal abundance. Non-native fish species are also responsible for reduction of fish size (e.g. total length), damage breeding ground and change food web structure and population structure [56,76-82]. The stock of *C. carpio* and *O. niloticus* are found to be well stable in the Ganga river basin [83-86,87], has stated that the important ecosystem services provided by fishes in the tropics. Each aquatic ecosystem is composed of multiple habitat kinds and environmental conditions which are determining the species loss and species invasions.

It may be concluded that the dramatic advances have been made recently in the study of biodiversity-ecosystem functioning relations. The establishments of non-native fish species are more successful in disturb system in contrast to relatively non perturbed, which is highly resistance to non-native species. The Paisuni river ecosystem functioning is to favour of non-native species. T. tor stocks suffer to degradation of ecosystem and rich abundance of *C. carpio* and *O. niloticus*. In addition, the population decline of Indian Major Carp (IMC) and T. tor, which may promote the removal of *C. carpio* and *O. niloticus* from the Paisuni river, India. A mixture of strategies will be essential to preserve freshwater biodiversity in the long term. Biodiversity and ecosystem functioning are interrelated via a surreal assemblage of species, habitat nature, environmental conditions, nutrient cycle, seasonal fluctuations and number of percipient invasive species with detonated frequency.

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