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Impact of Environmental Change on Fish and Fisheries in Warna River Basin, Western Ghats, India

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Abstract

The Western Ghats mountain range region in India is known for high biological diversity and endemism. Freshwater species on average are more endanger than terrestrial species. The Western Ghats are characterized by high fish taxonomic diversity. The study mainly focuses on the present status of the fish diversity, fishing activity and socioeconomic status of traditional fishermen community in Warna a tributary of River Krishna in its upper catchment in the Western Ghats region of south Maharashtra. The present fish diversity belonged to 4 orders, 10 families, 30 genera and 42 species. In Warna basin riverine ecosystems and fishing activity in the basin is increasingly influenced by anthropogenic activities. The major environmental impacts on fisheries are due to change in land use pattern, transformation in river flow regime, riparian habitat loss, invasion of exotic species, over fishing and agricultural expansion.

Keywords: Fish diversity, fishermen community, threats, environmental impacts.

Introduction

Rivers are one of the extensively studied ecosystems world over. It has been illustrated that these ecosystems are the most threatened ecosystem worldwide[1,2]. Rivers perform important ecological functions such as development of ecosystem; enhance productivity, natural flood control and species diversity conservation[3]. River ecosystems are complex mosaics of habitat types and environmental gradients, characterized by connectivity and complexity of organisms[4]. Natural disturbances like flood and fluvial process continually work together in riparian areas to create unique ecosystem that are essential for biological habitat diversity[5]. According to Allen[6] a healthy and intact riparian area not only protects stream structure but also stabilizes stream banks and riverine ecosystem. The natural and stable riparian ecosystems change when they are utilized by man. The anthropogenic alterations create ecological stresses on riparian ecosystems which are responsible for change in pattern of energy flow and also the movements of materials.

The mountain range of the Western Ghats being a high rainfall area in the Indian peninsula, south Maharashtra region receives heavy rainfall ranging from 4000 to 6000 mm during monsoon months (June - September) every year. Due to average altitude above 1000 m from MSL, Western Ghats are the origin of over 38 east flowing and 37 west flowing river systems in the peninsular India. This gives rise to several watersheds on the either side of this north- south mountain range. The riparian wetlands created by the timely and profuse precipitation serve vital ecological functions in the region. According to Western Ghats report there are 290 species of fresh water fishes belonging to 11 orders, 33 families and 106 genera, which having 196 endemic species and 13 endemic genera[7].

Habitat fragmentation is considered to be responsible for change in local biodiversity of the river, in recent years there are increasing reports of pollution causing massive fish kill, soil erosion and siltation, and agriculture expansion in the catchment area. River valley projects together with deforestation, mining, and changing agriculture patterns. Activities are responsible for degradation of riparian habitats. Developmental activities, mainly construction of dams and K.T weirs, water level fluctuations, industrial and urban pollution, and introduction of exotic species, sand mining, bank soil extraction for brick kilns are major threats responsible for rapid decline in natural riparian habitats and local biodiversity.

Traditionally inland fisheries in rivers provide livelihood to the local fishermen communities in the study region. Fish being a good indicator of aquatic habitat health and possible environmental change, the status of any river system can be determined by the quality and quantity of fish species reported from it[8]. There have been some studies related to the environmental changes in riparian system, in the Western Ghats. Many authors have recorded supporting observation[9-11]. From these studies it is revealed that even slight change in the watershed have inevitable impact on the biodiversity in the riparian systems.

Material and Methods

Warna is one of the major tributaries in the upper catchment of river Krishna, the main river system in peninsular India. The

total length of river Warna is about 170 km. There are around 86 villages on the banks of the river and its small tributaries. Warna drainage is relatively narrow but a well developed basin, from North West to South East (16^o 47' to 17^o 15' N and 73^o 30' to 74^o30' E). The river originates in the hilly region of the Western Ghats in south Maharashtra, about 2 km to the west of Patherpunj village at an altitude of 914 m MSL in Patan taluka of Satara district. After flowing most of its course as a boundary of the districts of Kolhapur and Sangli, Warna meets river Krishna near village Haripur in Sangli district. On the basis of the precipitation pattern in the catchment, the river basin can roughly be divided into three parts i.e. upstream in the hilly terrain, (from the origin up to Chandoli dam), Midstream (from Chandoli dam to Chavare village), and Downstream (from Chavare to Haripur village) (figure 1).

There are numerous springs and streams in the hilly upstream area which finally merge into Warna River. Kadavi and Morana are the two main tributaries of Warna in its upper basin. Kadavi originates at an altitude 701 m MSL in hills near Amba village and flows eastwardly for 35.4 km to join Warna near Sasegaon village. River Kadvi has three tributaries i.e. Shali, Potphugi and Ambarde. Morna the other tributary originates at 886 m MSL in Dhamanwada hills near Kondaiwadi village in the north in the middle catchment of Warna. Morna flows about 27.4 km before meeting Warna near village Mangle.

This study was aimed to evaluate the present status of fish diversity and fishing activity, as a part of assessment of the changing riparian habitats in Warna river system. Methodology adopted for the study was based on field investigations, fish catch analysis, and a social survey of the traditional fishermen communities along the entire Warna river system. The study focused on the present status of fish diversity, threats to fish habitats, ecological changes in the riparian system and socio-economic condition of the fishermen communities. The field study was carried out during December 2009 - March 2010. The survey of 49 fishermen was conducted, in 19 villages, where the traditional fishermen communities are still actively engaged in fishing activity.

Results and Discussion

Traditional fishermen communities and fishing activity: Fishing in freshwater wetlands is a traditional livelihood of some local communities in Maharashtra. These traditional Hindu fishermen communities in western Maharashtra include Mahadev-koli, Bhoi, Bagdi, Sankoli, and Gosawi. However, in Warna basin only three of these communities, namely Bhoi, Bagdi and Gosawi, are active. These are basically economically poor and socially backward communities. Because of their low income, low literacy rate and lack of any other occupational skills, the communities are vulnerable and totally dependent on diversity and availability of fish for their livelihood. The communities use traditional fishing gears such as fishing trap (Khavari), gill net (Kandali), drag net (Wadap), and cast net (Phekani).

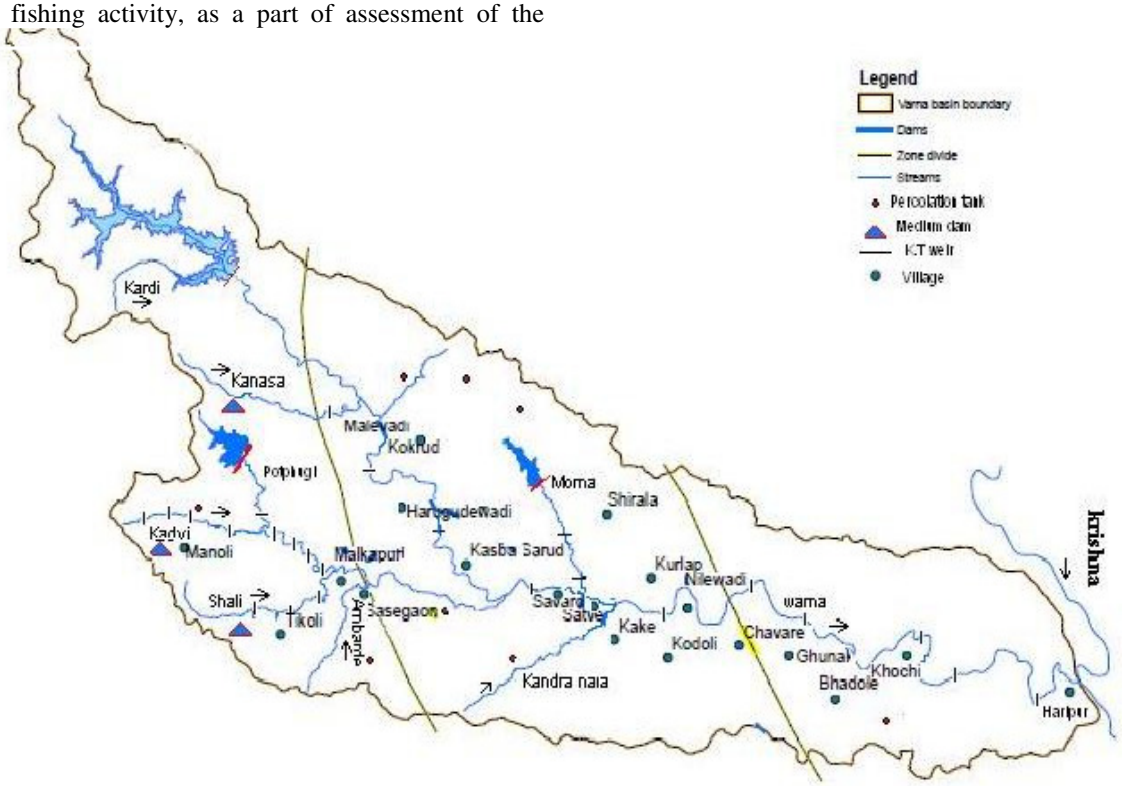

Figure-1
Wetlands in the Warna River Basin

However, use of dynamite is not uncommon these days for fishing in small village ponds, percolation tanks and river pools by the traditional fishermen but mostly by economically weaker people from other communities. The explosives used for fishing are easily available from adjoining mining and quarrying activities. This type of indiscriminate and destructive fishing activity adversely affects fish population in the river and tanks. This type of fishing is more active during summer months when concentration of fish gets isolated in depressions and pools in the dry river beds.

Change in the status of fish diversity: Any land use change in river catchment has a far reaching impact on the water course and riparian biota. Particularly in the rivers originating in the mountainous Western Ghats of south Maharashtra, their upper, mid and even lower catchments are more vulnerable due to the changing crop pattern from the traditional millet and paddy to irrigated cash crops like sugarcane. This has dramatically changed the entire scenario of landuse pattern in the catchments in the last three decades, Warna basin being no exception. As fish are excellent bio indicators of qualitative and quantitative change in the aquatic ecosystems; any slight change in the river character is reflected in their species diversity, distribution and abundance. The changing status of fish diversity from Warna River, as presented in this paper, is based on the experience and knowledge of the traditional fishermen interacted with in addition to the fishing data generated during the field survey. The changes observed in the fish diversity of Warna River and its tributaries, are summarised in tables 1, 2 and 3. Kalawar, and Kelkar[12] in their pioneering study on fishes of Kolhapur reported 71 fish species in early sixties, when the rivers in the region did not have as much destruction of the riparian habitats as today.

However, out of the 42 species of fish recorded in Warna river system during the study, 8 fish species (19.04%) are abundant, 26 species (61.90%) are common and 8 species (19.04%) are now rare. Comparing past status, out of the earlier 10 abundant species only 4 have retained the status. Apparently these four species i.e. *Garra gotlya, Labeo fimbriatus, Mystus malabaricus* and *Wallago attu* are either sturdy varieties to withstand the changes in riverine state or have been able to suitably adapt to the changing environmental conditions. Whereas 5 of the earlier abundant species whose status has downgraded to common are *Eutropiichthys vacha, Gonoproktopterus kolus, Labeo calbasu* , *Parambassis ranga,* and *Mystus cavasius* and the one *Salmostoma phulo* has even become rare.

Interestingly from the earlier 30 species with common status, now 4 have become abundant namely these species are *Catla catla, Cirrhina mrigala, Cyprinus carpio* and *Labeo rohita*. 20 have maintained the same status where as 6 have become rare. These species are *Botia striata, Chana marulius, Glossogobius giuris, Pseudotropius atherinoides, Rita pavimentata, Tor khudree.*

Out of the two rare species *Nemachilus botius* has become common and the other *Xenontodon cancila* has remained rare in river waters. However, this species is now abundant in village ponds and percolation tanks**.** Indian major carps species, *Catla catla* (Catla)*, Labeo rohita* (Rohu), *Cirrhina mrigala* (Mrigal), those were common earlier, have become abundant in most tanks and ponds in the catchment and lower reaches of the river. Same is true with the exotic common carp *Cyprinus carpio*, (silver carp) and *Ctenopharyngodon idella (Grass carp). Oreochromis mossambicus* (Tilap), which was not reported earlier in Warna River, has also become abundant. However, native fish species like *Botia striata, Chana marulius* and *Glossogobius giuris* are rarely found in the river any more (Ref: table 1 and 3).

A total of 71 fish were known to the local fishermen in Warna River. They belonged to 7 orders, 13 families, 2 sub families, and 39 genera (table 2). It is revealed that there has been drastic reduction in the fish diversity in the river system i.e. from the earlier recorded 71 species to present 42 species, a decline of 40.8%. This decline in fish diversity status is also evident in decline at order (42.8%), family (23.07%), and genera (20.51%) levels. There was no change in the sub families.

The present study is an attempt to find out declining trend and the current status of fish diversity in the Warna river basin over last 30 years. This is indicative and therefore, there is a need of further detailed study on habitat and catchment land use change to find out the major causes behind the change in the fish diversity.

Causes of change: Environmental degradation is responsible for damage in riparian habitats and decline in fish diversity. According to Gopalkrishnan[13] rapid increase in urbanisation and consequent increase in developmental activities during recent three to four decades together with unreliable rainfall and degradation of riparian vegetation have affected the flow regime and biodiversity of the rivers. Because of the increasing anthropogenic activities, freshwater ecosystems and species there in have suffered from stresses. As compare to the terrestrial ecosystem fresh water species are at higher risk of extinction[14,15].

Habitat Destruction: Riparian forest or vegetation is limited to the narrow streamline areas which serve a good habitat for the invertebrate and vertebrate organisms[16]. The riparian vegetation provides complex microhabitat by providing shade, trapping silt and sediments by anchoring roots which in turn supports a number of diverse organisms[17]. It is well documented that healthy and intact riparian forest not only protects river stream but it stabilizes river ecosystem and also help in stabilising the bank erosion[18]. The changing land use patterns in the adjoining catchment areas of Warna pose threat to the vulnerable riparian habitat. Loss of bank vegetation is a major problem observed in Warna river system, vegetation along the river banks in the middle and lower catchments are mainly damaged and at many places totally replaced by the increasing agricultural expansion.

Table-1
Past and present status of fish species in Warna river basin (A: Abundant, C: Common, R: Rare)

Sr.no	Scientific name	Local name	Common name	Past status			Present status		
				A	C	R	A	C	R
1.	*Aorichthys seenghala*	Singada	Long nose cat fish	-	+	-	-	+	-
2.	*Bagarius bagarius*	Khirit	-------	-	+	-	-	+	-
3.	*Barilius bendelisis*	Jorya	-------	-	+	-	-	+	-
4.	*Botia striata*	Waghmasa	Tiger loach	-	+	-	-	-	+
5.	*Catla catla*	catla	Catla	-	+	-	+	-	-
6.	*Chana marulius*	Maral	Murrel	-	+	-	-	-	+
7.	*Chana punctatus*	Kalamasa	Murrel	-	+	-	-	+	-
8.	*Channa orientalis*	Dokry	Dwarf murrel	-	+	-	-	+	-
9.	*Channa straita*	Mhgsha	-----	-	+	-	-	+	-
10.	*Cirrhina mrigala*	Mrigal	Mrigal	-	+	-	+	-	-
11.	*Cirrhina reba*	Bhagna	Carp	-	+	-	-	+	-
12.	*Clarious batrachus*	Mangur	Cat fish	-	+	-	-	+	-
13.	*Ctenopharyngodon idella*	Gavtya	Grasscarp	-	+	-	-	+	-
14.	*Cyprinus carpio*	Cyprinus	Cyprinus	-	+	-	+	-	-
15.	*Eutropiichthys vacha*	Khavalchor	Cat fish	+	-	-	-	+	-
16.	*Gagata itchkea*	Ichka	Itchaka	-	+	-	-	+	-
17.	*Garra gotya*	Mallya	------	+	-	-	+	-	-
18.	*Glossogobius giuris*	Kharpya	Goby	-	+	-	-	-	+
19.	*Gonoproktopterus kolus*	Kolshi	Kolshi	+	-	-	-	+	-
20.	*Hypothalymichthyes molitrix*	Chandera	Silvercarp	-	+	-	-	+	-
21.	*Labeo fimbriatus*	Tamber	Carp	+	-	-	+	-	-
22.	*Labeo calbasu*	Kanas	Calbasu	+	-	-	-	+	-
23.	*Labeo rohita*	Rohu	Rohu	-	+	-	+	-	-
24.	*Mastacembelus armatus*	Vam	Spring ell	-	+	-	-	+	-
25.	*Mystus cavasius*	Katerna	Cat fish	+	-	-	-	+	-
26.	*Mystus malabaricus*	Shingti	Cat fish	+	-	-	+	-	-
27.	*Nemachilus botius*	Chikli	Striped loach	-	-	+	-	+	-
28.	*Ompak pabo*	Kaliwanz	Butter cat fish	-	+	-	-	+	-
29.	*Ompak bimulatus*	Wanz	Cat fish	-	+	-	-	+	-
30.	*Oreochromis mossambicus*	Tilap	Tilapia	-	-	-	-	+	-
31.	*Parambassis ranga*	Kachaki	Glass fish	+	-	-	-	+	-
32.	*Perilampus atpar*	Sonulya	-----	-	+	-	-	+	-
33.	*Pseudotropius atherinoides*	Sura	Cat fish	-	+	-	-	-	+
34.	*Puntis ticto*	Bomri	Firefin barb	-	+	-	-	+	-
35.	*Puntius dobsonil*	Potil	Jerdons barb	-	+	-	-	+	-
36.	*Rasbora daniconius*	Dandali	Rasbora	-	+	-	-	+	-
37.	*Rita pavimentata*	Ghogrya	Cat fish	-	+	-	-	-	+
38.	*Salmostoma phulo*	Alkut	-----	+	-	-	-	-	+
39.	*Schizmatorhynchus nukta*	Naktya	-----	-	+	-	-	+	-
40.	*Tor khudree*	Mhasheer	Mahseer	-	+	-	-	-	+
41.	*Wallago attu*	Panga	-----	+	-	-	+	-	-
42.	*Xenontodon cancila*	Tokali	Gar fish	-	-	+	-	-	+

Table-2
Change in fish diversity status in Warna river basin (A: Abundant, C: Common, R: Rare)

Systematics	Past Status	Present status	(+/-) change	Change %
Order	7	4	- 3	42.85
Family	13	10	- 3	23.07
Sub-family	2	2	----	-----
Genera	39	30	- 8	20.51
Species	71	42	- 30	40.84

Table-3
Past and present status of the fish species in Warna river basin

Past		Present		
		A	**C**	**R**
A	10	4	5	1
C	30	4	20	6
R	2	--	1	1
Total	**42**	**8**	**26**	**8**

Soil erosion: The changing land use practices from traditional agriculture and enormous degradation of vegetation in middle and lower catchments are responsible for the vast change in the river system, which ultimately has resulted into increase in the natural rate of soil erosion on the banks and siltation of natural depressions and pools in the river bed[19]. As a result of the recent increase in the process of urbanisation and industrialisation in south Maharashtra, fertile river bank soil is used for the manufacturing of bricks. Majority of brick kilns are located in lower catchment of Warna basin (Bhosalewadi, Haripur village), and also in upper catchment along the Kadvi River. Some of the brick kilns are very close to river banks contributing to the destruction of river embankments and might be responsible in change in the course of the river in the future (figure 2).

Figure-2
Brick kilns along the river

Sand mining: Urbanisation has increased demand for river sand as a vital item in construction raw material. Most of the river beds in the state have been exploited as sources of fine aggregates for building construction. River sand and gravel are mined extensively from the river, and intensity of mining is high in the alluvial reaches of the main channels basically lower reaches of the rivers[20]. Enormous amount of sand is mined from lower catchment of Warna River near Kodoli, Chincholi and Haripur villages. Since most of the stretches in lower portion of Warna river have perennial water in the river due to KT weirs, sands from river beds are minned by suction pumps fitted on floats or on the banks. This rapidly increasing mechanised sand mining activity adversely affects the riparian biota, particularly benthic and littoral by gathering and pumping activity of river bed. The sand dumps on river banks and the approach roads cause serious damage to the entire riparian vegetation and fauna dependent on it (figure 3). Majority sand mining was observed in Haripur, Tandulwadi, Ghunki and Harugadewadi.

Figure-3
River bed sand mining at Haripur

Agriculture expansion: Agriculture expansion is one of the major threats to the river ecosystem. Numerous studies have documented that decline in water quality; habitat and biodiversity loss are because of increase in agricultural area within catchments[20]. Change in traditional agricultural crops like paddy to cash crops like sugarcane has drastically altered the land use pattern in Warna catchment in general and riparian catchment in particular which ultimately affects the valuable riparian biodiversity. Removal bank vegetation i.e. gallery trees and grasses on bank deposits for levelling of sugarcane fields has a non reversible impact on the ecology of the riparian habitats of Warna (figure 4).

Figure-4
Agriclture expansion along river

Water level fluctuation: Water level fluctuation is one of the major limiting factors of the river system habitats. Important physical factor in maintaining any healthy riparian habitat is the annual water level fluctuation regime in the river system. However, in the recent years due to construction of dams and weirs in the upper catchments, there is monthly, weekly and daily discharge in stream with significant impact on organisms in river bed. It is due to several factors such as the inconsistent rainy season, release of excess water from the dams, heavy irrigation for the sugarcane field, over use of lift irrigation through of K.T (Kolhapur Type weirs) weirs and dams. Due to increasing agricultural expansion along river system and subsequent increased demand of water, the number of dams and K.T. weirs are increased in Warna river system (30) besides periodic water level fluctuations, the K.T weirs across the Warna and tributaries like Kadvi, Morna, Shali form the barriers to free movement of most fish species, particularly during summer, and affect the reproduction of fishes in riparian system. This is also true to the entire food chain of organisms in the riparian habitats in the Warns river system (figure 5).

Pollution: Main cause of pollution is increasing human population along wetlands[21]. Pollution is another major and rapidly growing threat to the rivers in Maharashtra. This is largely due to the release of untreated sewage from cities and towns into the river as well industrial effluents being discharged in the river system. Increasing industrialisation, particularly agro based industries like sugar factories and distilleries. Warna River is facing similar pollution problems with cumulative impacts. The industrial waste from pulp and paper industry was known to directly release in to the Warna River near village Kodoli .Domestic sewage water of cities and villages also pollute the Warna River. Mass fish mortality is often observed near Haripur village as the sewage from Sangli city is directly released in to the river. Another dimension of pollution in Warna river system like any other river in the region is release of increasing quantity of agrochemicals in form of chemical fertilisers and pesticides used for the cash crops as non point pollution from the entire catchment. This is bound to have negative impact on riparian biota.

Over fishing: Over fishing is known to contribute serious depletion in fish diversity, density and distribution patterns in the riparian systems. Due to declining nature of fishing in the recent years as a result of several anthropogenic factors, fishes of all age groups, small and large size are caught by fishermen in the competitive fishing operations which in the near future may cause serious decline in fish stock in the river system.

Socioeconomic status of fishermen community: A social survey was conducted to have a better understanding of the ecological and socio-economic status of the fishermen community in Warna basin. There are three traditional fishermen communities in Warna basin namely Bhoi, Bagdi and Gosawi. In last two decades local but non traditional fishermen communities are also engaged in fishing activity. The dominant traditional fishing communities in the warna basin were Bhoi followed by Gosawi and Bagdi. It was observed that Bhoi community is distributed in the entire Warna river basin, while Gosawi were mainly restricted to upper and middle catchments; Bagdi community was limited to middle and lower catchment of the river system.

Figure-5
Typical Kolhapur Type (K.T.) weir at Sawarde

Traditionally fishing was done by these communities mainly for subsistence, however, now in most cases it is carried out as a major livelihood with other occupations. It is revealed that though Gosawi are engaged in traditional fishing, now they do not solely depend on it as the main livelihood due to the inconsistency in the fish catch. Most of the members of this community also deal with metal scrap business and other activities.

As expected the literacy level in all the three communities was much lower than the average literacy level in the state. The least educated community among them was Bagdi. More percentage of illiterates belonged to senior age group in all communities. Bagdi and Gosawi communities are relatively less exposed to higher education. One of the important observations of the study is the revelation that majority of the fishermen now are forced to depend on other occupations for living. This indicates that due to negative environmental impacts on the riparian system the traditional occupation of fishing is no longer sustainable in Warna basin. There is also a possibility of other more lucrative options are locally available today to some of the members of the communities.

It was also observed that only Bhoi community are still intensely involved in fishing while at times doing another work. Gosawi and Bagdi on other hand relied more on other occupations more than fishing as compared to Bhoi. The fishermen from these two communities had to depend on diverse petty jobs. In the upper catchment Bhoi community is economically more backward and some of them had to depend only on fishing for example Bhois in Arle and Kokrud villages solely depended on fishing and therefore are poor. This is because of non availability of suitable alternatives to fishing activity in the remote area and the traditional lifestyles. As a

result of declined fish catch in the recent years the fishermen communities had to depend on alternate occupations to supplement their earnings. Five such alternatives were reported. Self employment was the major source of supplementary income followed by labour, trade, marginal farming and petty jobs.

It was observed that in some villages (Sawe, Wadgaon, Sarud, Bhedsgaon) reasonably good fishing activity was carried out in the percolation tanks and village ponds. However, these fishermen were outsiders (from other states) and not from Warna basin. It was observed that apparently the local fishermen cannot compete with these outsiders in tank fishing and therefore had to shift to other occupations for livelihood.

During the study efforts were made to confirm fishermen's personal efficiency, expertise, and experience in earning income from traditional fishing in different age groups. Out of the four age groups of fishermen studied individuals of middle age group i.e. 36-43 years dominated (41.3%), followed by adult group (24 %,), senior citizens (20%) and youth (15 %). Considering only one or two individuals from each fisherman household are involved in fishing, the income from this activity was quite meagre. The income from fishing showed that most (47.8%) make a modest monthly earning of Indian Rs1001-2500 per head. Whereas some (33%) fisherman made up to Rs 2501 to 4000 per month. Only few (13%) fishermen earned over Rs 4001 per month. Some of the non traditional fishermen are doing fishing only for subsistence and not for commercial purpose. As most of the fishermen families were no longer solely dependent on income from fishing and had other sources of income, their family income does not reflect income from fishing activity alone. However, Gosawi families seem to be better off as compared to other two fishermen communities due to alternate incomes.

Study on the catchment wise fishing activity in different wetlands in Warna basin revealed that riverine fisheries dominated in all the three river catchments followed by ponds and dams. Fishing in percolation tanks and village ponds was mainly observed in upper and middle catchments. The traditional fishing activity in the river basin was mostly restricted to rivers by all the three communities (98%). This was followed by fishing in village ponds (26.5%), percolation tanks (8.2%), and in dams (2%). This clearly indicates that since most fish in rivers, deterioration of riparian ecosystems have a direct negative impact on fishing and livelihood of the fishermen.

The majority of the respondents reported that they undertake fishing activity independently, particularly in the rivers. Only a small fraction of fishermen (10%) were involved in group fishing activity in rivers, village ponds and percolation tanks. Sizable percent of fishermen (20.4%) were involved in both the activities.

Most of the fishermen (88%) do fishing throughout the year i.e. in summer, rainy and winter seasons. They revealed that the maximum fish catch in a year was in summer followed by rainy season and negligible catch in winter. The higher catches in summer months are attributed to lowering of water levels and increased fish concentrations in river pools and river bed depression. Upstream fish migration for breeding mainly contributes rainy season catches.

Use of different fishing gear in Warna basin revealed that fishermen do not depend exclusively on any one type of fishing gear, but depending on local aquatic habitats combinations of fishing gears were used. In upper catchment all types of fishing gears are used. Whereas in middle catchment most of the fishermen used gillnet for fishing. In lower catchment, fishermen are mainly dependent on cast net and gill net. Use of bag net observed in middle catchment of Warna basin is not reported exclusively in middle stream flow but it is used in upper reaches of Morna River (which is a part of the middle catchment of Warna basin). The drag net is not practiced in the river but mostly for the group fishing in percolation tanks and village ponds.

These days a variety of traditional and contemporary fishing methods are used for fishing in the basin, no community however depends on any one type of fishing gear. It is observed that Bhoi community uses gill net, drag net and cast net. Gosawi's mostly used gillnet and Bagdi community used gill net and cast net. Non traditional fishermen often used gillnet and hook-and-line. According to the fishermen, in some regions dynamites were used for mass fishing in lakes and river. This indiscriminate killing of fish of all age groups has adversely affected and declined fish population in rivers and lakes. However, no respondent agreed that he was involved in dynamite fishing anytime.

Most fishermen (86%) possessed their own fishing gear. Bagdi community, being net weavers themselves, do not depend on other sources for fishing gear material. Fishermen in Warna basin have established cooperative societies for fishing in the river, lakes and village ponds. The State Fishery Department gives subsidies to the society for procurement of fishing gears, nets and also provides subsidy for construction of their houses. As most of the fishermen were members of some fishery cooperative society, they receive 5 kg of nylon yarn per fisherman for their own fishing net.

In general, most fishermen opined that fish catch in the basin has gradually declined in the past twenty years. The test of significance (Z test) of proportionality was used to find out the fishermen perception about the status of fish diversity in the Warna basin. At 5% level of significance the calculated Z value was found to be greater than tabulated Z value. (Z_{cal} 7.1 > Z_{Tab} 1.96) .This infers that the fish diversity has decreased over a period of time. As per the middle age (36-45 years) fishermen (90%), which is actively engaged group in fishing for about past 20 years, there is significant decline in fish quality as well as the quantity of catch. The same reason was endorsed by most (70%)

of the experienced senior fishermen. In addition they stressed that some local fish species common earlier, are now rarely seen in the river. This is attributed to the over fishing conditions. However, Introduction of exotic species in river, like is also responsible in decrease in diversity of the native fish species in the river. Apparently some of (*Oreochromis mossambicus, Cyprinus carpio*) the introduced fish species are more adaptative to the changing riparian habitats than the native species.

It was noticed that the reasons given by the fishermen for the current decline in fish diversity and fish catch vary mainly with the site in the catchment, and literacy level, experience and knowledge of fishermen. Most of the fishermen (46%)opined that decline in fish diversity is due to the water level fluctuation, followed by dams(40%), pollution(15.6%) and K.T.weirs(29%); only few (2%) opined that it was because of siltation of pools in river beds. Even the illiterate fishermen are aware of the negative impacts of pollution on fish in the river (figure 6). Figure caption as well as figure need improvement as it does not reflect the contents of title clearly.

Catchment wise study revealed that the reasons behind declining of fish diversity vary with location. In upper catchment mostly fishermen opined that water level fluctuation followed by dams, K.T. weirs, are responsible for the declining fish catch and diversity, where as in middle catchment fishermen believed that the decline is because of water level fluctuation, dams, K.T. weirs and pollution, only few opined that it is due to siltation. In the lower catchment major reasons quoted were water level fluctuation, dams and pollution. Pollution is mainly observed in the middle and lower catchment of the basin. The domestic sewage of most of the villages and towns like Malkapur are directly released into the river without any treatment. In lower catchment industrial waste from Warna Nagar Township was also released into the river which adversely influenced the quality of water and fish diversity (figure 7).

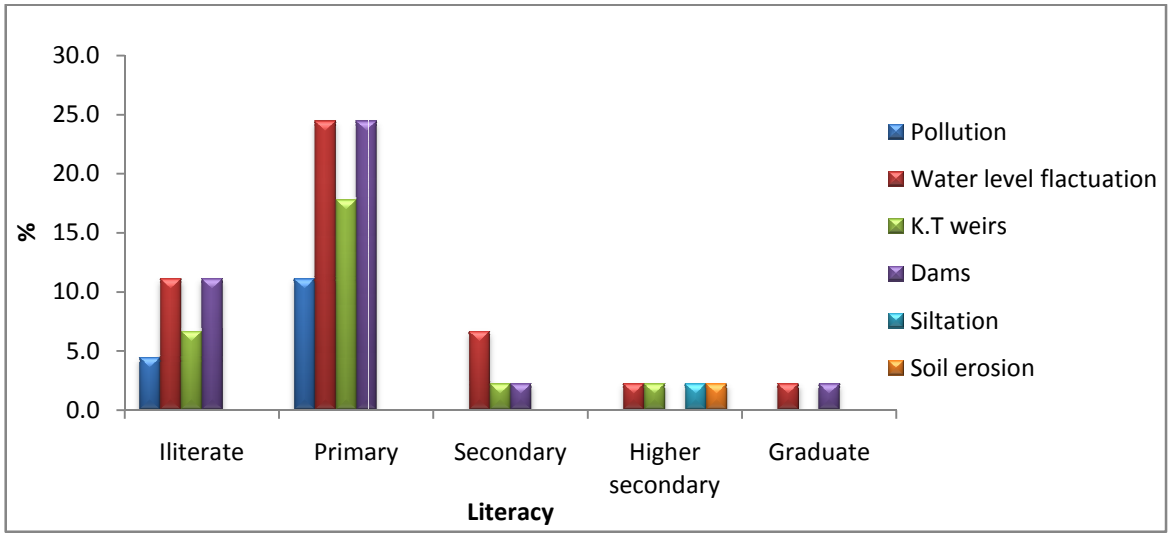

Figure-6
Literacy Level among Fishermen and Reasons for Fish Decline

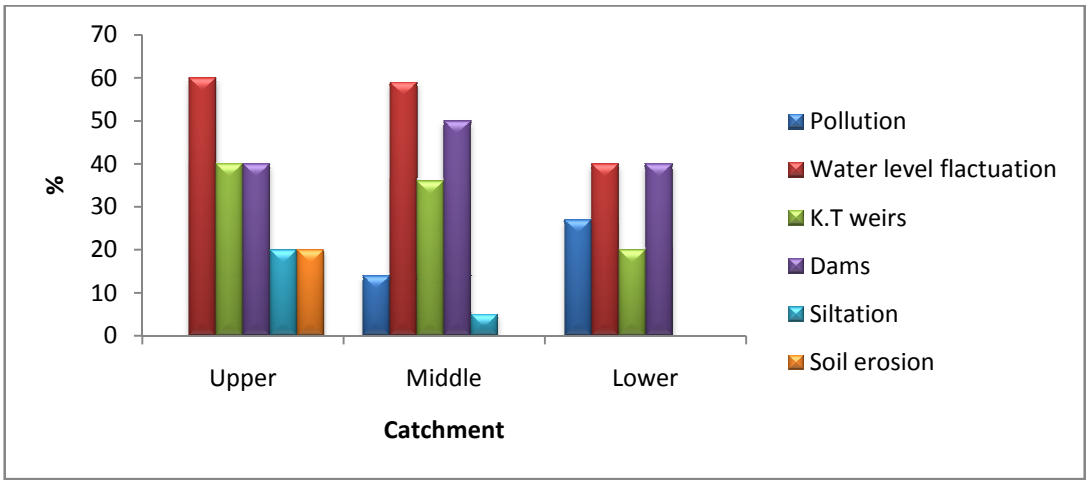

Figure-7
Reasons for decline in fish diversity along the course (lower, middle and upper reaches) of the river

Due to the low income of fisherman and apathy of government towards their socio-economic issues and difficulties, the new generation of fishermen is not much eager to continue the traditional livelihood. Only some are expected to continue the practice, this too is not by choice but as there are not many options of other livelihood. Particularly in Bhoi community though new generation is being educated and engaged in other occupations, most of them were still actively engaged in fishing simultaneously. The new generation of Bhoi and Gosawi community are however, engaged in service and trade and have found new sources of income. It was interestingly observed that the young generation from fishermen communities is not engaged as labourers.

Conclusion

Warna river system is undergoing a gradual negative change in the quality of its riparian ecosystems and biodiversity affecting fish populations. Reclamation of riparian areas is a major problem found throughout the Warna River system. The changing land use practices, increasing population, agricultural expansion and pollution are major threats to the riparian ecosystem. Particularly in the flood zone, encroachment in riparian area is one of the threats, and due to the loss of natural vegetation along the river margin, soil erosion takes place and this result in loss of habitat sites in river system has drastically impacted biodiversity. As socio-economic status of the fishermen in this region entirely depends upon the fish diversity and availability in the river system, it is observed that due to severe decrease in fish diversity and yield in the recent past, large number of fishermen families had left their main traditional occupation of fishing and shifted towards other occupation for livelihood. Economically introduced fish species in the percolation tanks and village ponds in the basin give more benefits to the fisherman, but intrusion of non traditional fisherman communities in this occupation, has adversely affected the socio- economic status of the traditional fishermen community.

Recommendations: There is urgent need to protect the riparian ecosystems in Warna basin, as any similar river in the upper catchment in the Western Ghats. Apart from the biodiversity and ecological value, the conservation of these habitats is very much and directly linked to the livelihood security of the people in this region. During the study it was realised that the important River Regulation Zone (RRZ) legislation (2009) was not known to the fishermen, people or concerned government officials. Apparently there is no comprehensive disaster management plan despite having an active seismic sensitive zone area and catchment of large dam in warna basin. Efforts should be made on government as well as local levels to prepare and implement both the activities judiciously by involving locals, concerned govt. officials, experts and NGOs. It is still possible to rejuvenate the fish diversity and stocks to near natural level, provided strict measures are taken to protect the environment and conserve riparian habitats by local people's participation.

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