

Sustainability Challenges for Traditional Fisheries: Bycatch Impact of Gillnets in River Burhi Gandak

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ABSTRACT

A comparative study was conducted for different types of gillnets operated in selected sampling sites i.e. Lauria, Sikta, Sagauli, Mehshi, Ahiyarpur, Musahri, Muraul, Bakhri and Khariya of river Burhi Gandak. The maximum length were observed for gillnet N₇ and minimum for N₁ and N₂. Mesh size of gillnets operated in river Burhi Gandak varied from 15.0 mm to 40.0 mm and hanging co-efficient i.e. 0.7 were found for all type of gillnets. The total catch per day from all type of gillnets from selected sampling sites were found 200.55 kg. Out of total catch 132.05 kg were found as main catch and remaining 68.50 kg

were found as bycatch. The contribution of main catch and bycatch in total catch of gillnets was found 65.843% and 34.156% respectively. In main catch the contribution of *Labeo rohita* was found highest i.e. 23% and lowest for *Cirrhinus mrigala* (12%). The highest bycatch was observed from *Catla catla* (27%) and lowest for *Ompak pabda* (11%). CPUE varied from 2.73 to 8.78 kg for total catch, 1.10 to 5.92 kg for main catch and 0.5 to 3.83 kg for bycatch. One-way ANOVA was carried out and significant difference was found in bycatch of different gillnets. Gillnet N₁ with very small mesh size had more bycatch in comparison to main catch. Hence, it may be concluded that bycatch is inversely proportional to mesh size of gillnets. Therefore, it is recommended that smaller mesh size gillnets shall not be permitted in the river Burhi Gandak.

Keywords Bycatch, Traditional, Gillnet, Fishing, Efficiency.

INTRODUCTION

Gillnet is one of the oldest passive gears operated throughout the world in both inland and marine water bodies. Gillnet is a size selective fishing gear accounting for 20% of the global capture fisheries (1). It is the only gear which is operated in accordance with the article VII of Code of Conduct for Responsible Fishing of UN FAO (Kumar *et al.* 2013). Gillnets are widely used throughout the world and are favored in artisanal fisheries because they are relatively inex-

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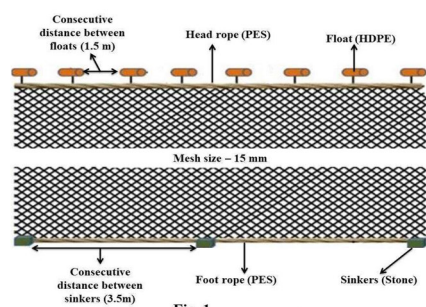


Fig. 1

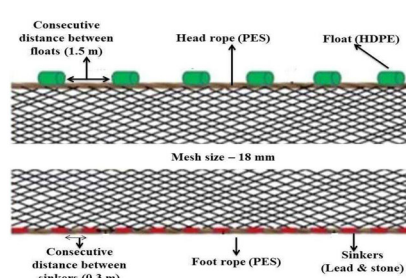


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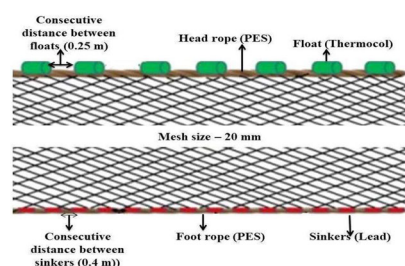


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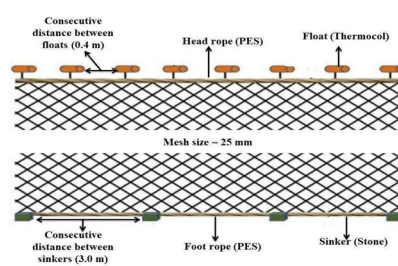


Fig. 4

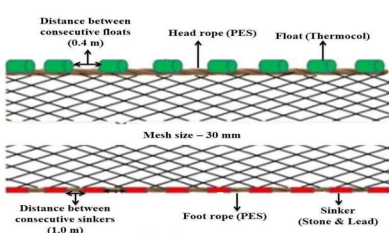


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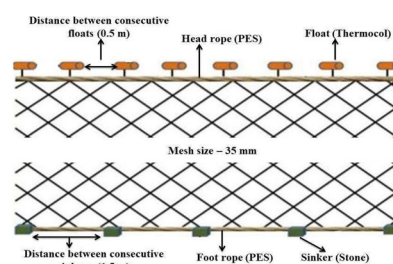


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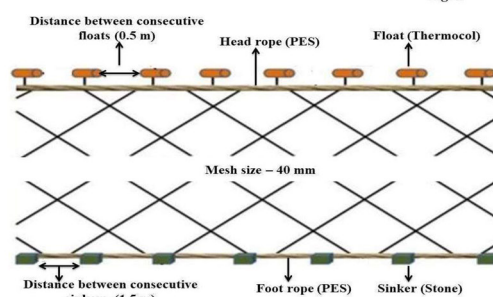


Fig. 7

Figs. 1— 7. Gillnet (N_7).

pensive, easily constructed and deployed and quite effective for various species, especially schooling teleosts (Yalei *et al.* 2018, Grimaldoa *et al.* 2019). Bycatch is one of the major and serious threat to the conservation of fish species that is going to be endan-

gered (Brownell *et al.* 2019). It is also referred to an incidental catch causing mortality and injuries to the non-target species, is an issue affecting the ecosystem and survival of marine population (Read 2013). The issue of bycatch develop awareness and interest

Table 1. Design features of gillnet operated at river Burhi Gandak, Bihar.

Features	Net						
	N ₁	N ₂	N ₃	N ₄	N ₅	N ₆	N ₇
Length (m)	30.0	30.0	40.0	46.0	45.0	48.0	50.0
Depth (m)	2.5	2.5	3.0	3.0	3.5	3.5	3.5
Webbing material	PE	PE	PE	PE	PE	PE	PE
Webbing thickness (mm)	0.66	0.66	0.66	0.66	0.66	0.66	0.66
Rope material	PES	PES	PES	PES	PES	PES	PES
Float material	HDPE	HDPE	Thermocol	Thermocol	Thermocol	Thermocol	Thermocol
Consecutive distance between float (m)	1.5	1.5	0.25	0.4	0.5	0.5	0.5
Sinker material	Stone	Lead and Stone	Lead	Stone	Lead and Stone	Stone	Stone
Consecutive distance between sinker (m)	3.5	0.3	0.4	3.0	1.0	1.5	1.5
Mesh size (mm)	15	18	20	25	30	35	40
Hanging Co-efficient	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Soaking duration (hrs)	13-14	13-14	13-14	13-14	13-14	13-14	13-14
Availability in sampling sites	Muraul, Bakhri & Khagaria	Muraul, Bakhri & Khagaria	Musahri & Muraul	Ahiyarpur & Musahri	Sagauli, Mehsi, Ahiyarpur & Musahri	Sikta & Sagauli	Lauria & Sikta

globally to develop guideline on management of bycatch discard reduction (FAO 2014). In general, there are three types of bycatch ; normal, cryptic and ghost fishing. Normal bycatch is a non-target

Table 2. Mean quantity of main catch and bycatch of gillnets from all sampling sites of river Burhi Gandak.

	Mean length (cm)	Avg wt (g)	Net							Total
			N ₁	N ₂	N ₃	N ₄	N ₅	N ₆	N ₇	
Main catch										
<i>Labeo rohita</i>	50	3000.0	-	-	3.0	3.0	6.0	8.0	10.0	30.0
<i>Catla catla</i>	60	3500.0	-	-	3.5	4.0	5.0	6.0	8.0	26.5
<i>Cirrhinus mrigala</i>	30	800.0	1.0	1.5	1.5	1.0	2.0	3.5	5.0	15.5
<i>Ompak pabda</i>	25	200.0	-	0.5	1.0	0.5	0.8	1.0	1.5	5.3
<i>Sperata seenghala</i>	25	120.0	-	1.0	1.5	0.25	0.5	1.0	1.0	5.25
<i>Wollago attu</i>	22	150.0	0.5	0.5	0.5	0.20	0.5	0.8	1.0	4.0
<i>Ctenopharyngodon idella</i>	60	3000.0	-	3.0	3.0	3.0	2.5	4.0	5.0	20.5
<i>Hypophthalmichthys molitrix</i>	50	2500.0	2.5	-	-	2.5	3.0	5.0	7.0	20.0
<i>Puntius sp.</i>	18	80.0	1.5	1.5	0.8	0.4	0.3	0.3	0.2	5.0
Total			5.50	8.00	14.80	14.85	20.6	29.60	38.70	132.05
Bycatch										
<i>Labeo rohita</i>	25	150.0	4.0	3.5	2.5	2.5	2.0	1.0	1.0	16.5
<i>Catla catla</i>	28	200.0	3.5	3.5	3.0	3.5	2.5	1.0	1.0	18.0
<i>Cirrhinus mrigala</i>	20	100.0	3.5	3.0	2.5	2.5	1.0	0.5	0.5	13.5
<i>Ompak pabda</i>	15	50.0	2.0	2.0	1.5	1.5	0.5	-	-	7.5
<i>Puntius sp.</i>	10	20.0	4.0	3.5	2.0	1.5	1.0	-	-	12.0
Total			17.0	15.5	12.50	11.50	7.00	2.50	2.50	68.50
G. Total (A+B)			22.5	23.5	27.30	26.35	27.6	32.10	41.20	200.55

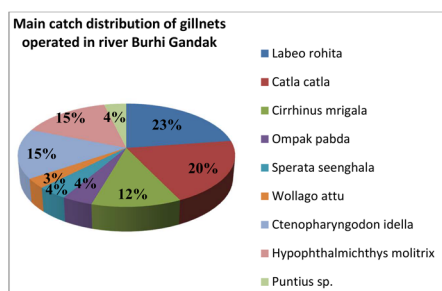


Fig. 8

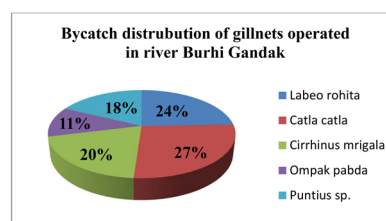


Fig. 9

Fig. 8. Main catch distribution of gillnets. Fig. 9. Bycatch distribution of gillnets.

species trapped in nets, alive or dead, during the hauling process. Cryptic bycatch constitutes of organisms entangled in fishing gears and develops injury and die after trying to escape from the gears (Leland *et al.* 2013). Bycatch in gillnets became the primary driver of population declines in many species of marine mega fauna, including elasmobranchs, sea turtles, seabirds and marine mammals (Zydelis *et al.* 2013, Huang 2015, Werner 2018). It has been observed that there is an urgent need to reduce the amount of bycatch by getting support from fishing industry. Reduction in bycatch may affect efficiency of gillnets so seasonal closure of fishing activity have a role to play in managing impact of gillnets (Regular *et al.* 2013).

To promote sustainable harvesting, ideally gillnets would be configured and fished across appropriate spatio-temporal scales that maximize catches of the permitted species and their sizes. Burhi Gandak is a left bank tributary of the Ganga river. It is meandering in nature and flows in the southeast direction. It originates in the terai area of Chautarwa Chaur near

Bishambharpur, West Champaran district in Bihar state. Traversing a distance of about 400 km in the alluvial plain, Burhi Gandak joins Ganga near Gogri Jamalpur, Khagaria district of Bihar. The Burhi Gandak basin is spread over the West Champaran, East Champaran, Muzaffarpur, Samastipur, Begusarai and Khagaria district of Bihar. The important tributaries of Burhi Gandak are Masan, Ramrekha, Singha, Pandai, Urai, Konhra, Parah, Gadh, Tiar, Jamni, Dhanauti, Nuna, Kedana, Baler, Sikta, Tilawe, Manjhar, Hawa, Dudharwa, Dera. (Singh *et al.* 2018). The main objectives of this study were to document the total catch, main catch and by catch from different types of gillnet and comparing the by catch among different gillnets operated in selected sampling sites of river Burhi Gandak.

MATERIALS AND METHODS

Study area

The present study was carried out at nine sampling

Table 3. CPUE of gillnets for total catch, main catch and bycatch.

Type of gill nets	No. of gears	Total catch		Main catch		Bycatch	
		Total catch (kg)	CPUE (kg)	Main catch (kg)	CPUE (kg)	By-catch (kg)	CPUE (kg)
N ₁	5	22.5	4.5	5.50	1.10	17.0	3.4
N ₂	6	23.5	3.92	8.0	1.33	15.5	2.58
N ₃	10	27.30	2.73	14.8	1.48	12.5	1.25
N ₄	3	26.35	8.78	14.85	4.95	11.5	3.83
N ₅	6	27.60	4.60	20.6	3.43	7.0	1.17
N ₆	5	32.10	6.42	29.6	5.92	2.50	0.5
N ₇	8	41.20	5.15	38.70	4.84	2.50	0.31

Table 4. Fishing efficiency for all type of gillnets operated in river Burhi Gandak.

Type of gillnets	CPUE	Duration of operation (hrs)	Fishing efficiency (kg/hr/gear)
N ₁	4.5	8.0	0.56
N ₂	3.92	8.0	0.49
N ₃	2.73	7.0	0.39
N ₄	8.78	16.0	0.49
N ₅	4.60	8.0	0.58
N ₆	6.42	12.0	0.54
N ₇	5.15	9.0	0.57

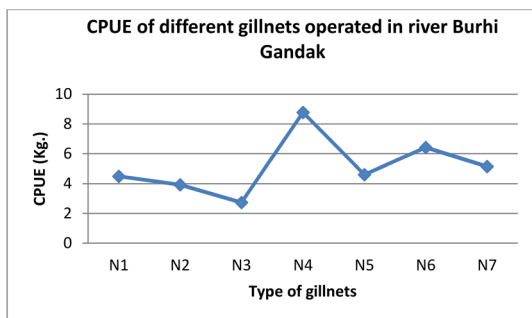


Fig. 10. CPUE of different gillnets.

sites of river Burhi Gandak. The sampling sites are located at Lauria (26.9881° N, 84.3943° E), Sikta (27.0262° N, 84.6813° E), Sagauli (26.7617° N, 84.7412° E), Mehshi (26.3563° N, 85.0985° E), Ahiyarpur (26.1486° N, 85.3993° E), Musahri (26.1264° N, 85.3917° E), Muraul (26.0188° N, 85.4040° E), Bakhri (25.5994° N, 86.2605° E) and Khagaria (25.5045° N, 86.4701° E). The total length of river Burhi Gandak is 400 km. The operation of gillnet is a year round activity in this river. Gillnet operated in this river have different mesh sizes such as 15 mm (N_1), 18 mm (N_2), 20 mm (N_3), 25 mm (N_4), 30 mm (N_5), 35 mm (N_6) and 40 mm (N_7). Gillnets of different mesh size group were randomly selected for the collection of catches.

Technical details and design features of different gillnets being operated at different sampling sites of the river Burhi Gandak were documented. The design features includes total length (m), depth (m), color of twine, size of twine (mm), mesh size (mm), material of head rope and foot rope, diameter of ropes (mm), material of floats and sinkers, inter distance between two consecutive floats and sinkers (cm), Soaking duration (hrs). Sampling and identification of species were done during present investigation for quantitative assessment of bycatch. Main catch and bycatch for gillnets were segregated and species identification was done using FAO Fisheries and Aquaculture Technical Paper (Fischer 2013).

Catch effort

Catch per unit effort (CPUE) was generated for main catch, bycatch and total catch for the sampling sites

of river Burhi Gandak. The CPUE was calculated by using the formula: $Catch = CPUE \times Effort$ (Appelman 2015). Catch efforts data were collected from the sampling sites of river Burhi Gandak for gillnets. The catch per unit effort (CPUE) was taken as catches from the net of 30 m long, for a soaking duration of 10 hours and the catch was expressed as weight in kg. Estimation of bycatch, mean quantity of bycatch and proportion of bycatch to main catch were estimated for different gillnets. Mean of bycatch was also calculated (Jayalath and Turner 2021). Proportion of bycatch to the main catch was expressed as percentage in terms of weight.

Data analysis

Analysis of variance (ANOVA) was carried out for bycatch and main catch for selected gillnets operated in different sampling sites of river Burhi Gandak to test for variability at 5% level of significance. Duncan Multiple Range Test was used to separate means. Statistical Package for Social Science (Version 20.0) was used.

RESULTS AND DISCUSSION

Gillnet was found one of the major gear operated in river Burhi Gandak for harvesting of aquatic organisms. The gillnets operated in Burhi Gandak river varied in length from 30.0 m to 50.0 m (Figs. 1 – 7). The maximum length were observed for gillnet N_7 and minimum for N_1 , N_2 . The webbing material, webbing thickness, soaking duration for all gillnets were observed same i.e. polyethylene (PE), 0.66 mm and 13 – 14 h respectively. Mesh size of gillnets operated in river Burhi Gandak varied from 15.0 mm to 40.0 mm and hanging co-efficient i.e. 0.7 were found for all type of gillnets. The consecutive distance between floats and sinkers varied from 0.25 to 1.5 m and 0.3 to 3.5 m respectively (Table 1).

The design features of gillnet is dependent on several factors such as length of net depends on width of river, mesh size and soaking duration of net depends on availability of fish and their size. During gillnet operation the netting material should not be visible to the organism that's why thinner twine i.e. 0.66 mm were used for construction of webbing

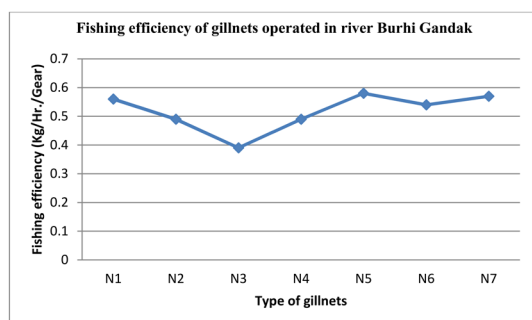


Fig. 11. Fishing efficiency of different gillnets.

material. The largest mesh size were observed for gillnet N₇ because it get operated at nearby origin of the river where fish stock size is large. For Gillnet N₁ and N₂ mesh size is small due to availability of fewer amounts of fish.

The total catch per day from all type of gillnets from selected sampling sites were found 200.55 kg. Out of total catch 132.05 kg were found as main catch and remaining 68.50 kg were found as bycatch. The contribution of main catch and bycatch in total catch of gillnets was found 65.843% and 34.156% respectively. In main catch the contribution of *Labeo rohita* was found highest i.e. 23% followed by *Catla catla* (20%), *Hypophthalmichthys molitrix* (15%), *Ctenopharyngodon idella* (15%) and *Cirrhinus mrigala* (12%). In case of bycatch highest contribution was observed from *Catla catla* (27%) followed by *Labeo rohita* (24%), *Cirrhinus mrigala* (20%), *Puntius* sp. (18%) and *Ompok pabda* (11%). It has been observed that same fish species like *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*, *Ompok pabda* and *Puntius* sp.

harvested as both main catch and bycatch because smaller size of same species also get considered as bycatch (Figs. 8, 9). The maximum main catch was observed from gillnet N₇ whose mesh size was largest i.e. 40.0 mm and minimum main catch was observed from gillnet N₁ whose mesh size is 15.0 mm. In case of bycatch maximum was observed from gillnet N₁ i.e. 17.0 kg and minimum was from gillnets N₆ and N₇ i.e. 2.5 kg.

The gillnet N₇ got operated in upper most stretch of the river Burhi Gandak where unharvested fish stock was available. Due to high stock size contribution of main catch was more than bycatch from this net. In case of gillnet N₁ whose contribution in main catch was lesser than bycatch because it got operated in lowermost stretch of the river where the fish stock size was very poor.

A catch per unit effort (CPUE) was generated for main catch, bycatch and total catch for all the gillnets (Table 2). Among all the gillnets operated in river Burhi Gandak the gillnet N₄ was contributing maximum. Catch Per Unit Effort (CPUE) for total catch, main catch and bycatch i.e. 8.78 kg, 4.95 kg and 3.83 kg respectively because of smaller mesh size (25 mm). The minimum CPUE for total catch contributed by gillnet N₃, for main catch N₁ and for bycatch N₇ (Table 3) (Fig. 10).

Fishing efficiency determines the suitability of gear in particular water body for harvesting of aquatic organisms. Among all the gillnets operated in river Burhi Gandak gillnet N₅ shown highest fishing efficiency i.e. 0.58 kg/hr/net due to upper stretch region of river and medium size of mesh of webbing of the

Table 5. Analysis of variance for main catch and bycatch collected from all type of gillnets operated in river Burhi Gandak.

		Sum of squares	df	ANOVA		
				Mean square	F	Sig
Main catch	Between groups	4528.476	6	754.746	113.060	.000
	Within groups	186.918	28	6.676		
	Total	4715.394	34			
Bycatch	Between groups	1037.571	6	172.929	47.988	.000
	Within groups	100.900	28	3.604		
	Total	1138.471	34			

net. The fishing efficiency of gillnet N₃ shown lowest i.e. 0.39 kg/hr/net (Table 4) (Fig. 11).

The statistical analysis of collected data indicates the significant differences among the main catch and bycatch for all the type of gillnets operated in river Burhi Gandak. Table 5 presents one-way ANOVA with Duncan test where comparing the difference in main catch and bycatch for all type of gillnets.

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