

SPECIAL CONSIDERATIONS FOR EFFECTIVE FISH PASSAGES SUITABLE TO NEPAL



Fish ladder choked with rockfall , sand and saplings etc (**a drought condition** in California, source; <https://seimkuruc.com>)

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- Introduction
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- Results & Discussion
 1. Fish passages successful abroad ?
 2. Why western experiences fails in South Asia ?
 3. Special consideration for effective fish passages
 4. Role of Nepal Agricultural Research Council
 5. Way forward: what might works for *win-win* situation to hydropower & fish production

INTRODUCTION



- 3 river basins, 1 river system
- 2.5% of total covered by water bodies



Source: TB Gurung



Kali Gandaki Fish Hatchery in Beltari

Source: Gurung TB (2016): Agriculture and Food Security Journal

Historical, Religious & Social Identity

- In *Puran* & Vedic literatures --- fish is "First Avatar" of Lord Vishnu, the most intellectual and peace loving God.

FISH Symbolizes Power & Prosperity

- In front of the marriage procession, indicating that the Bridegroom family status.



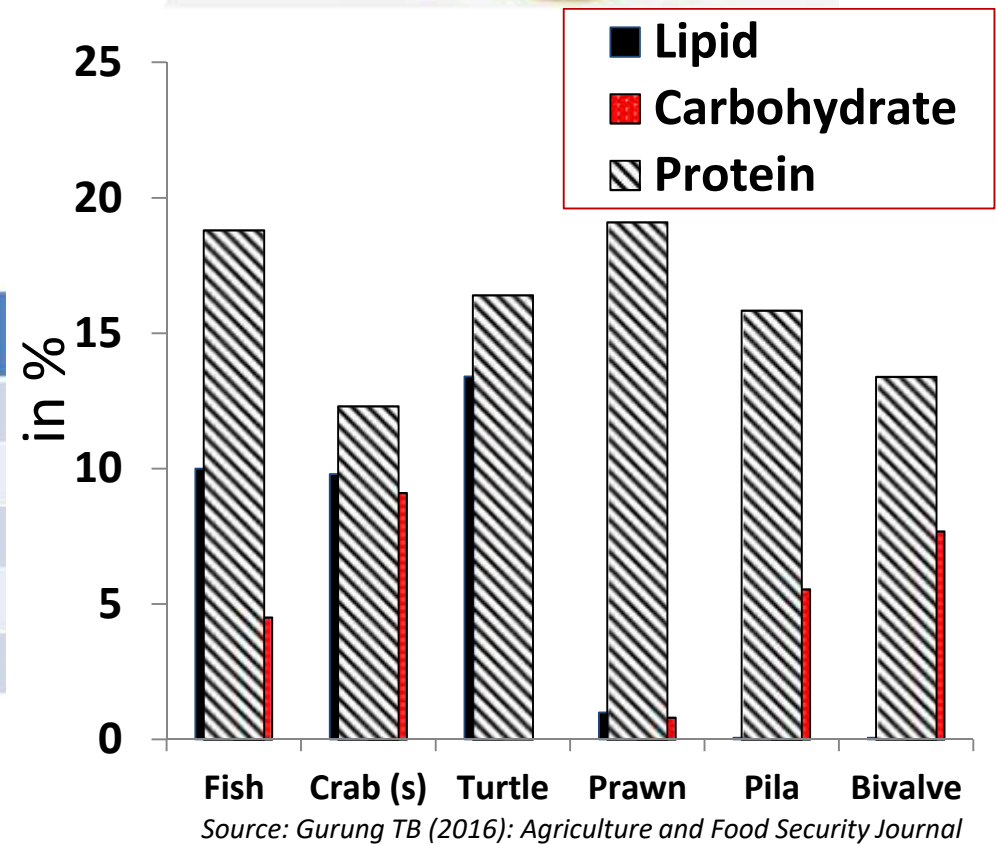
- Food & nutrition security is the prime concept
- Health benefit of Omega-3: the major trigger



Comparison of Omega-3 levels in fish & other meats

Nutrients	Unit	Farmed salmon	Wild Salmon	Carp	Tilapia	Rainbow	Chicken	Beef
Protein	g100g	20	20	18	20	19.44	19	21
Lipids	g100g	13	6.3	5.6	1.7	4.27	15	12
Water	g100g	65	69	76	78	74	66	65
Ash	g100g	1.1	2.5	1,5	0.9	1.38	0.8	1
ω-3	mg100g	1966	1436	350	91	700	40	3

Source: USDA 2012



Nepalese Rivers : Source of Aquatic Biodiversity

- 232 fin fish – 217 Ind spp
- 9 spp of crabs
- 3 sps of shrimp
- 50 sps of mollusk (25 edible)
- 53 spp of frogs
- 47 spp of reptiles
- 193 spp of aquatic birds
- 84 spp of aquatic plants spp
- Aquatic mammals (Dolphin, Otter etc)
- **Huge hydropower potentiality**



Photo: Wagle

Statement of the problems

THE ECOLOGY OF DAM REMOVAL

A Summary of Benefits and Impacts

- Despite of such potentiality & huge shortage of power & food.
- The hydropower is employment, income & livelihood, however, fish ladder are a big question on sustainability.
- “No development without environment. Development cannot take place at the cost of ecology and that green nod will be given only after "fair" and "transparent" assessment of projects”: J Natrajan



Bednarek, Angela. 2001. "Undamming Rivers: A Review of the Ecological Impacts of Dam Removal." *Environmental Management* 27(6):803-814.).

Objective

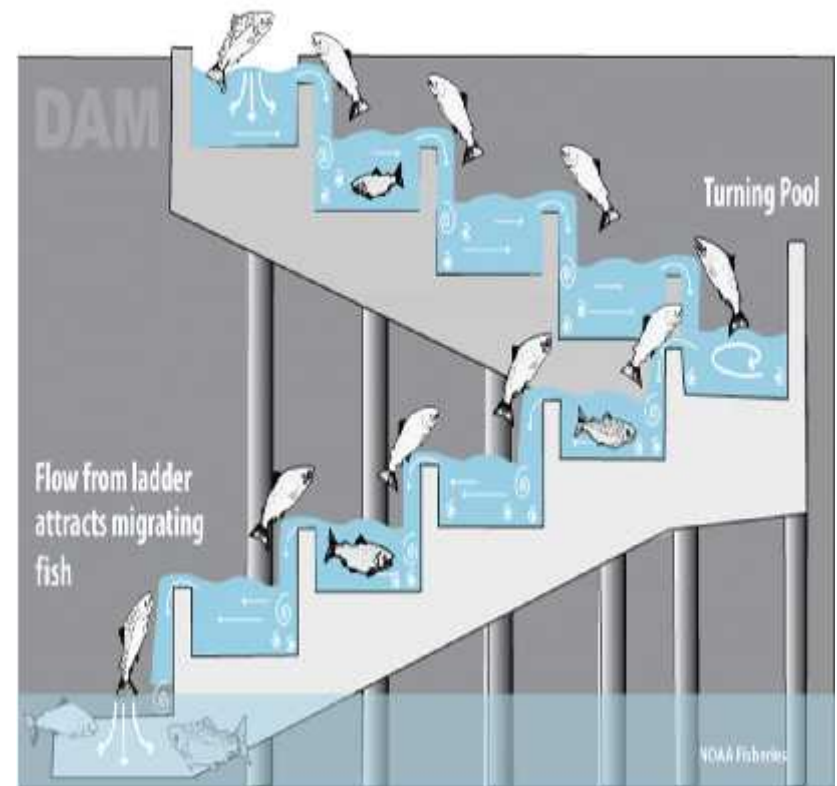
- Review on performance of fish passages to suggest a *win-win* modality for integrated power and fish production in Nepal

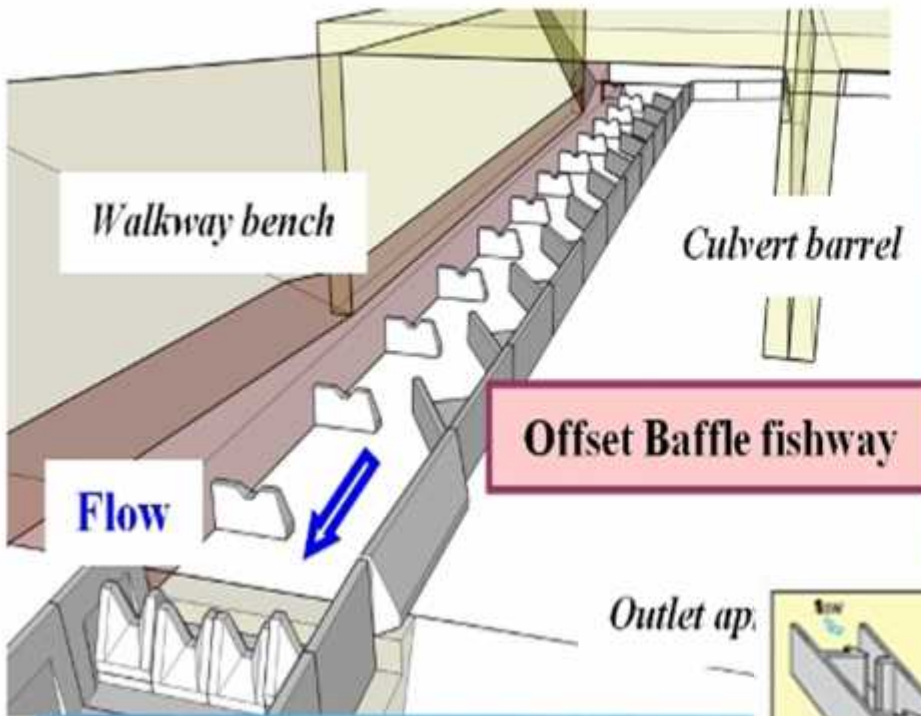
Materials & Methods

- Literature search on fish passages for review
- Data of Kali Gandaki Hydropower and Fisheries

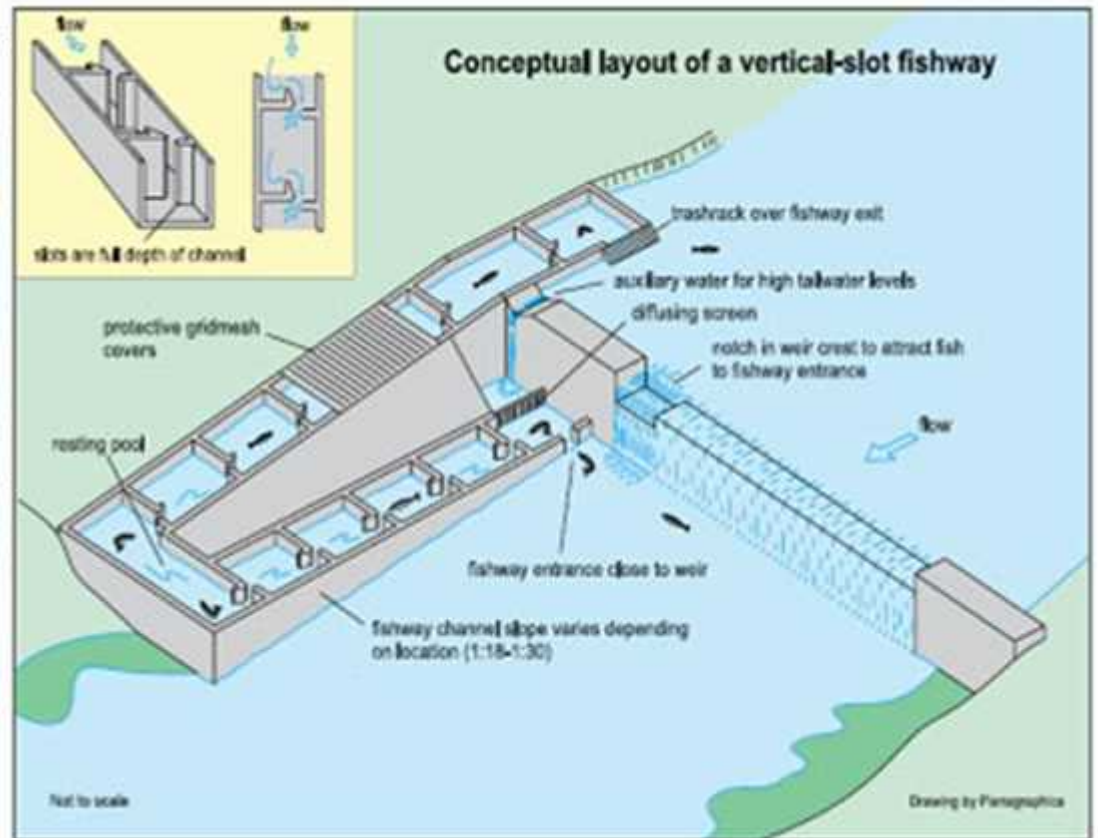
There are 6 main types of fish ways: world wide

- Pool and weir
- Baffle fish way (Denil, Larinier)
- Alaskan Steep pass, or other baffle configuration)
- Fish elevator
- Rock-ramp fish way
- Vertical-slot fish passage
- Fish siphon
- Fish hatchery



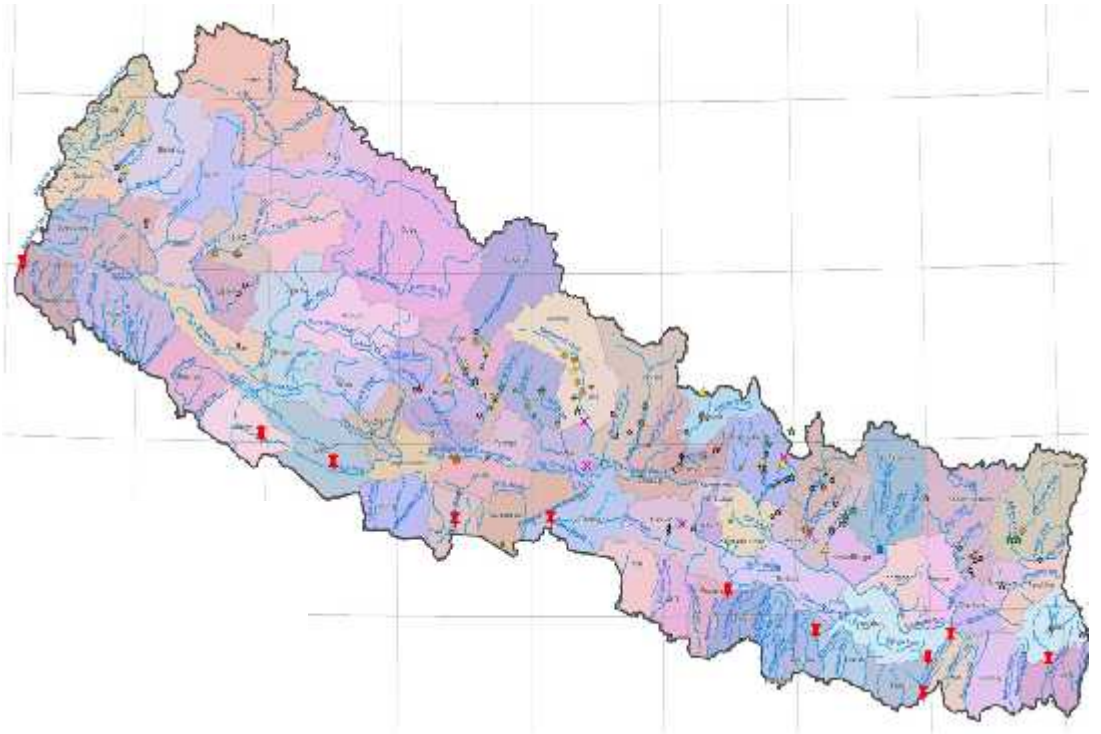


Fish elevator



Cross dams in Nepal

The cross dam projects (210) in different rivers of Nepal (NEA 2013):
84 in operation,
34 Under Construction,
92 proposed



Location of Cross Dam in Different Rivers in Nepal

Fish Passages in Nepal

- Fish ladder/pass design were probably derived from the European or North American pool type & vertical slot passes (Jha 2007).



Fish ladder in (A) (Shrestha) (B) Andhikhola

- However, the fish ladders or passes are not functioning well, the discharge through the pass is too low compared to the river flow.

- Kali Gandaki (NEA/NARC 2010)
- Jhimruk
- Andhikhola (Jha 2007)
- Trishuli NEA (Shrestha)
- Koshi barrage (Yadav 2002)
- Chandra Nahar (Rajbanshi 2002)
- Trijuga (Jha 2007)
- Gandak barrage (Rajbanshi 2002)

Fish passages proposed & implementation status

Project	Measure committed	Current practice	Remarks
Kali Gandaki A	<ul style="list-style-type: none"> • Trapping & hauling, • Fish hatchery • Minimal in-stream flow (4m³/s), • Trash rack 	<ul style="list-style-type: none"> • Fish hatchery: 5 species bred, and 5 in observation 	Reduction in fish population/diversity
Mid. Marsyangdi	<ul style="list-style-type: none"> • Fish hatchery • Minimal flow (1m³/s), • Entrainment 	No measures in application	Stocking of 50,000 fry produced at KG hatchery
Kulekhani-1	No EIA	No measures	Down permanently dry except in flood
Babai IP	No EIA	<ol style="list-style-type: none"> 1. Fish ladder 2. Water release (1m³/s) during dry season 	Last 3 pools of ladder are silted
Tinau	No EIA	No fish pass facility	
Trishuli Hyd	No EIA		

.....Fish passages proposed & implementation status

Sikta IP	Fish Ladder	Location of ladder not appropriate
Phewa HI project	No pass facility	Fry Stocking
Tanahun (Storage)	<ol style="list-style-type: none"> 1. Fish hatchery 2. Min. flow (2.4m³/s) 3. Trash rack 4. Fish habt mgmt 	
Khimti Hydropower	<ol style="list-style-type: none"> 1. Ladder 2. Stock imp. species 	No fish ladder?
West Seti storage (proposed)	Hatchery	
DudhKoshi Storage (proposed)	Hatchery	
Up Karnali (Proposed) run-of the river	Hatchery	Pool & weir type Fish ladder



Dam of Middle Marsyangdi Hydropower : downstream of the dam is virtually dry

Source: ADB (2014)

Some important riverine fishes of Nepal



Sahar, Tor



Asala, *Schizothorax* spp.



Katle, *Neolissocheilus hexagonalepis*



Gardi, *Labeo dero*

Photo source: Baidya

Fishes of Nepal's Rivers



Source: Newspapers (2015, 2016),

Source: SK Wagle

Source: Newspapers (2015)



Activities of fish hatchery functioning under Kali Gandaki River Hydropower



Jalkapur, *Pseudeotropius murius*



Gonch, *Bagarius bagarius*

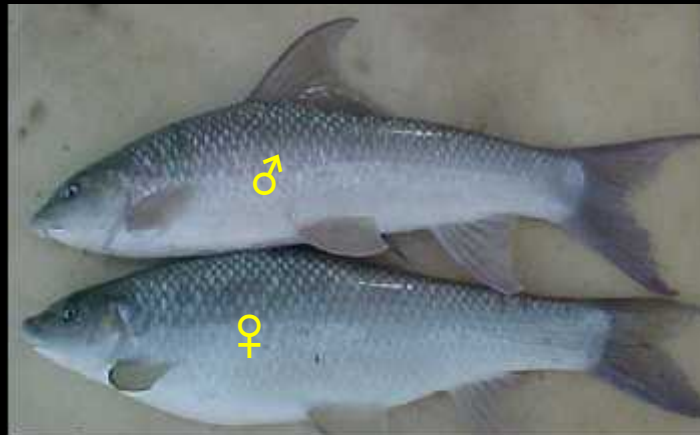


Rajbam, *Anguilla bengalensis*

Photo source: Baidya



Brood fish Selection in Pokhara and Trishuli



Gardhi (*Labeo dero*)

Photo source: Baidya

Breeding Technologies for Native spp



Labeo dero



Photo: TBG



Egg stripping



Milt addition



Fertilized eggs

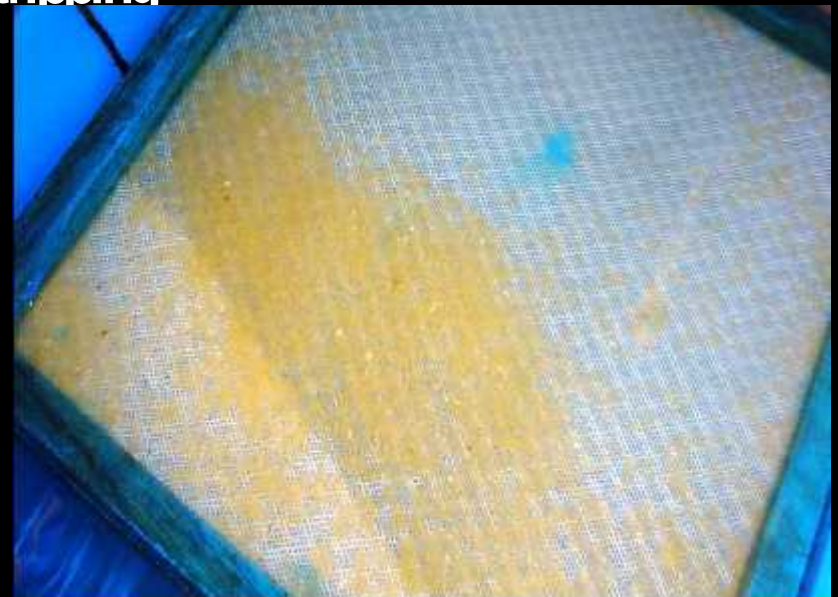
Photo source: Lalit & TBG



Gonadal Stripping



Egg incubation



Fertilized Eggs

Photo source: TBG

Breeding of indigenous Sahar



Photo source: TBG

Gain in public confidence for biodiversity conservation



Creation of conducive environment for river regulation

Source: Kali Gandaki Fish Hatchery



Source: Kali Gandaki Fish Hatchery

Fish tagging before release in Kaligandaki River



Source: Kali Gandaki Fish Hatchery

Fingerlings Released in Kali Gandaki River

Source: Dr. Arun Baidhya, Office, Incharge, Kaligandaki Fish Hatchery, Beltari, Syangja

	<u>03</u>	<u>04</u>	<u>05</u>	<u>06</u>	<u>07</u>	<u>08</u>	<u>09</u>	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>
T. putitora	20	40.5	80	122.9	160	110	260	92	25.5	-	-
Shizothorax	16	37	18	22	150	20	50	-	25	-	-
A. hexa	30	60	45	64.4	55	630	-	-	-	-	-
L. dero	40	300	470	155.9	510		390	392	30	404	305
Rohu	-		500	47	-		-	-		-	-
Hade	-				15,		110	371		84	230
Buduna	-				5,		-	-			
Lahare	-				5		-	-			
Other	-			40	-		-	-			
Total	106	437	663	452.2	765	760	810	855	80.5	488	535

Source: after Gurung and Baidya (2010, ICIMOD)

Updated list of endemic fish species (16) of Nepal

Fish Species	Author	Year	Where
<i>Myersglanis blythii</i>	Jayaram	1991	Pharping
<i>Psilorhynchus pseudechenies</i>	Menon & Datta	1962	Dudh Koshi
<i>P. nepalensis</i>	Conway & Mayden	2008	Rapti, Seti
<i>Pseudeutropius murius batarensis</i>	Shrestha	1981	Trishuli
<i>Schizothoraichthys macrophthalmus</i>	Tarashima	1984	Rara Lake
<i>S. nepalensis</i>	Tarashima	1984	Rara Lake
<i>S. raraensis</i>	Tarashima	1984	Rara Lake

Source: ADB (2014)

Cont...Updated list of endemic fishes of Nepal

<i>Batasio macronotus</i>	Ng & Edds	2005	River Sapta Koshi
<i>Pseudecheneis crassicaudata</i>	Ng & Edds	2005	Mewa Khola (River Tamor)
<i>P. serracula</i>	Ng & Edds	2005	Seti, Kali Gandaki, Narayani, Mahakali & Karnali
<i>P. eddsi</i>	Ng	2006	Mahesh Khola (Trishuli)
<i>Erethistoides ascita</i>	Ng & Edds	2005	Mechi, Kankai, Trijuga, Koshi
<i>E. cavatura</i>	Ng & Edds	2005	Dhungra, Rapti, Narayani
<i>Balitora eddsi</i>	Conway & Mayden	2010	Karnali
<i>Neoanguilla nepalensis</i>	Shrestha	2008	Narayani
<i>Turchinoemacheilus himalaya</i>	Conway, Edds, Shrestha & Mayden	2011	Indrawati, Kali Gandaki, Narayani

Source: ADB (2014)

Fish species (21) of Nepal under IUCN Red list

Sci. Name	Com Name	Nep. Name	Status
Glyptothorax kashmirensis			Critically Endangered
Schizothoraichthys nepalensis	Snow trout	Tikhe Asla	Critically Endangered
Schizothoraichthys raraensis	Rara Snow trout	Asla	Critically Endangered
Tor putitora	Golden Mahseer	Sahar	Endangered
Physoschistura elongata		Suiree	Vulnerable
Puntius chelynooides	Dark Mahseer	Halundae	Vulnerable
Schistura prashadi		Gadela	Vulnerable
Schizothorax richardsonii	Snow trout	Buche Asla	Vulnerable
Ailia coila	Gangetic Ailia	Patsi	Near threatened

Source: ADB (2014)

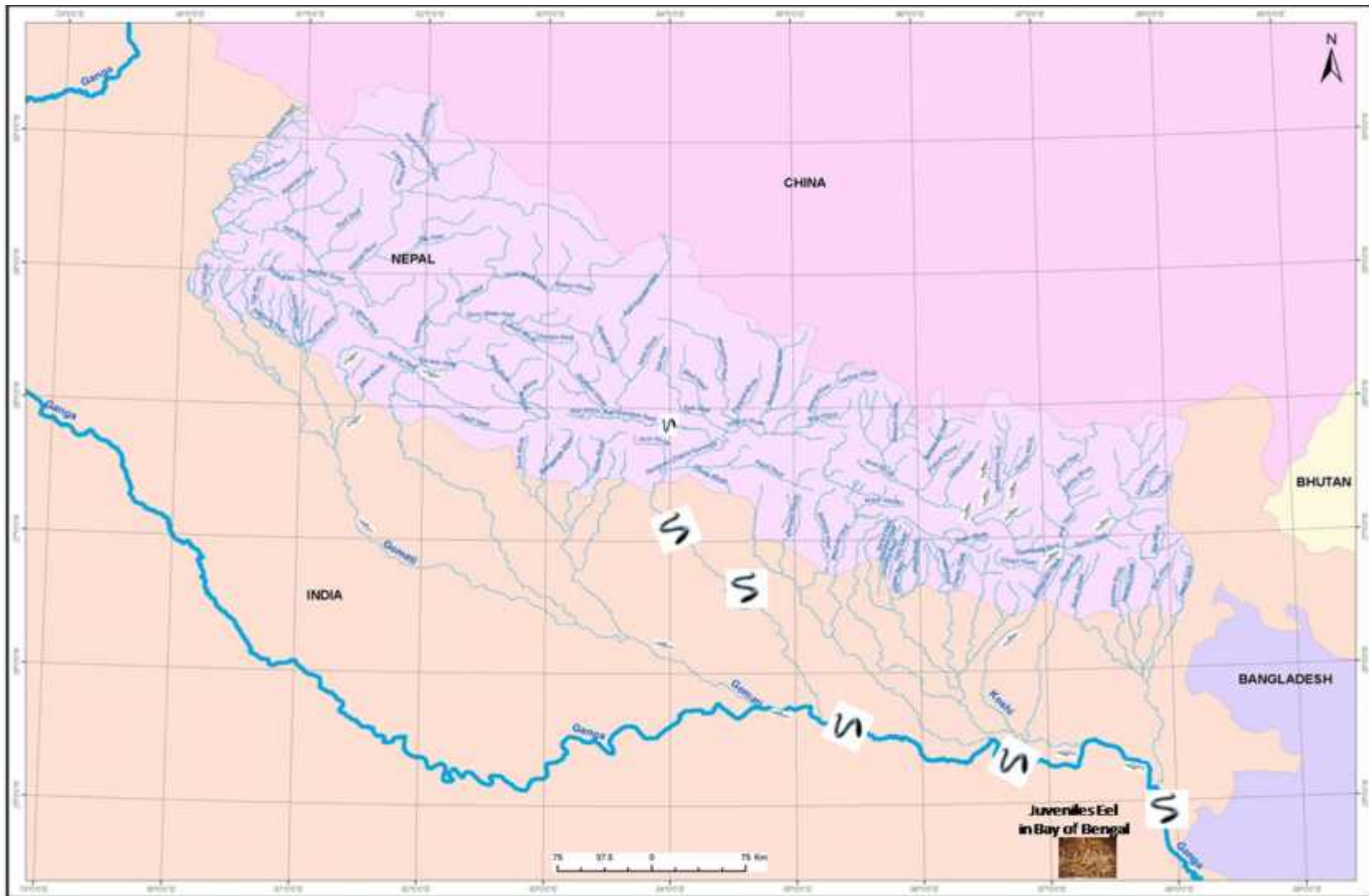
Cont.... Fish species of Nepal under IUCN Red list

Bagarius bagarius	Goonch	Gouch	Near threatened
Bagarius yarrelli	Goonch	Gouch	Near threatened
Balitora brucei	Gray's Stone Loach	Patthartata	Near threatened
Chitala chitala	Featherback	Chittal	Near threatened
Ctenops nobilis	Frail Gourami		Near threatened
Garra rupecula		Buduna	Near threatened
Labeo pangusia	Pangusia, Labeo	Theed	Near threatened
Neolissochilus hexagonolepis	Copper Mahseer	Katle	Near threatened
Ompok bimaculatus	Butter Catfish	Nauni	Near threatened
Ompok pabda	Pabda Catfish		Near threatened
Tor tor	Red-finned Mahseer,	Ratar/Sahar	Near threatened
Wallago attu	Whiskered Catfish	Buhari	Near threatened

List of Spp. (10) recommended for legal protection

<u>Scientific name</u>	<u>Com. name</u>	<u>Distribution</u>
<i>Acrossocheilus hexagonolepis</i>	Katle	Koshi, Gandaki, Karnali, Mahakali
<i>Chagunius chagunio</i>	Rewa	Koshi, Gandaki, Karnali, Mahakali
<i>Tor putitora</i>	Mahseer	Koshi, Gandaki, Karnali,
<i>Tor tor</i>	Sahar	Gandaki, Mahakali
<i>Danio rerio</i>	Zebra macha	Gandaki, Karnali,
<i>Schizothorax plagiostomus</i>	Buchhe asla	Koshi, Bheri, Gandaki, Karnali,
<i>Schizothorax richardsonii</i>	Asala soal	Koshi, Gandaki, Karnali,
<i>Schizothoraichthys progastus</i>	Chuche asala	Koshi, Gandaki, Karnali,
<i>Psilorhynchus pseudecheneis</i>	Tite macha	Koshi
<i>Anguilla bengalensis</i>	Rajabam	Koshi, Gandaki, Karnali,

Long Distance Route of Migratory Fish (*Anguilla* spp, *Tor putitora*) & Mammal, Dolphin (*Platanista gangetica*)



Source: ADB (2014)

Fish Passages Successful in Western World ?

- **MOST FISH PASSES ARE UNSUCCESSFUL IN USA (BROWN ET AL. 2013)**
- **SOME SUCCESSFUL MIGHT BE DUE TO**
 - **TARGETED TO ONLY FEW FISH SPECIES (BROWN ET AL. 2013)**
 - **MORE SOCIALLY COMMITTED PLANNERS & ENGINEERS**
 - **BY LAW -- MONITORING AGENCIES EXAMINE SUCCESS**
 - **PROBABLY LESS IMPOVERISH POPULATION**
 - **NO SPECIFIC ETHNICITY FOR CAPTURING INLAND FISH**
 - **INLAND FISHES MAY BE NOT THAT ATTRACTED AS MARINE**
 - **POWER GENERATED ONLY FROM LARGE RIVERS**

Why Western Experiences Fails in South Asia ?

- Inadequate information on:
 - A) Socio-economics,
 - B) Fish diversity,
 - C) Familiarity with aquatic life &
 - D) Site selection



Why Western Experiences Fails ?

- Altitudinal gradient of rivers, thus dams & fish passes (As more than 45 000 large dams (height >15 m) had been constructed worldwide by the end of the last century (Nilsson et al. 2005) .
- The western rivers are mostly gentle but hostile here
- Lack of clues on water flows, connectivity & e-flows
- Great disparity of flow in dry & wet season

Why Western Experiences Fails ?

- Fish pass a new technology in Nepal : Very few ladder experts try to know the Himalaya in the context of fish ladder.
- Socio-economics
- Less water in fish ladders & passes causing “mismatch between fish way operation and timing of fish movements (Leeuwen et al. 2016), discharge, climate, torrential river behaviour, or maintenance, poor commitment,
- No operation manual from fish perspective
- Fish ladders is only a ‘legal safety net’
- In west people mostly practice ‘catch & release’ instead ‘catch & eat’ ideology

Special Considerations : Social Aspects

- Understand social dynamism & dependency on fish
- No oceanic resources for fisheries production
- 10-12% of population comprised of 18 ethnic communities depending on fish & aquatic resources (IUCN 2004)
- Rivers & water bodies are ultimate destinations for food gatherer & collector

Special Considerations : Technical Aspects

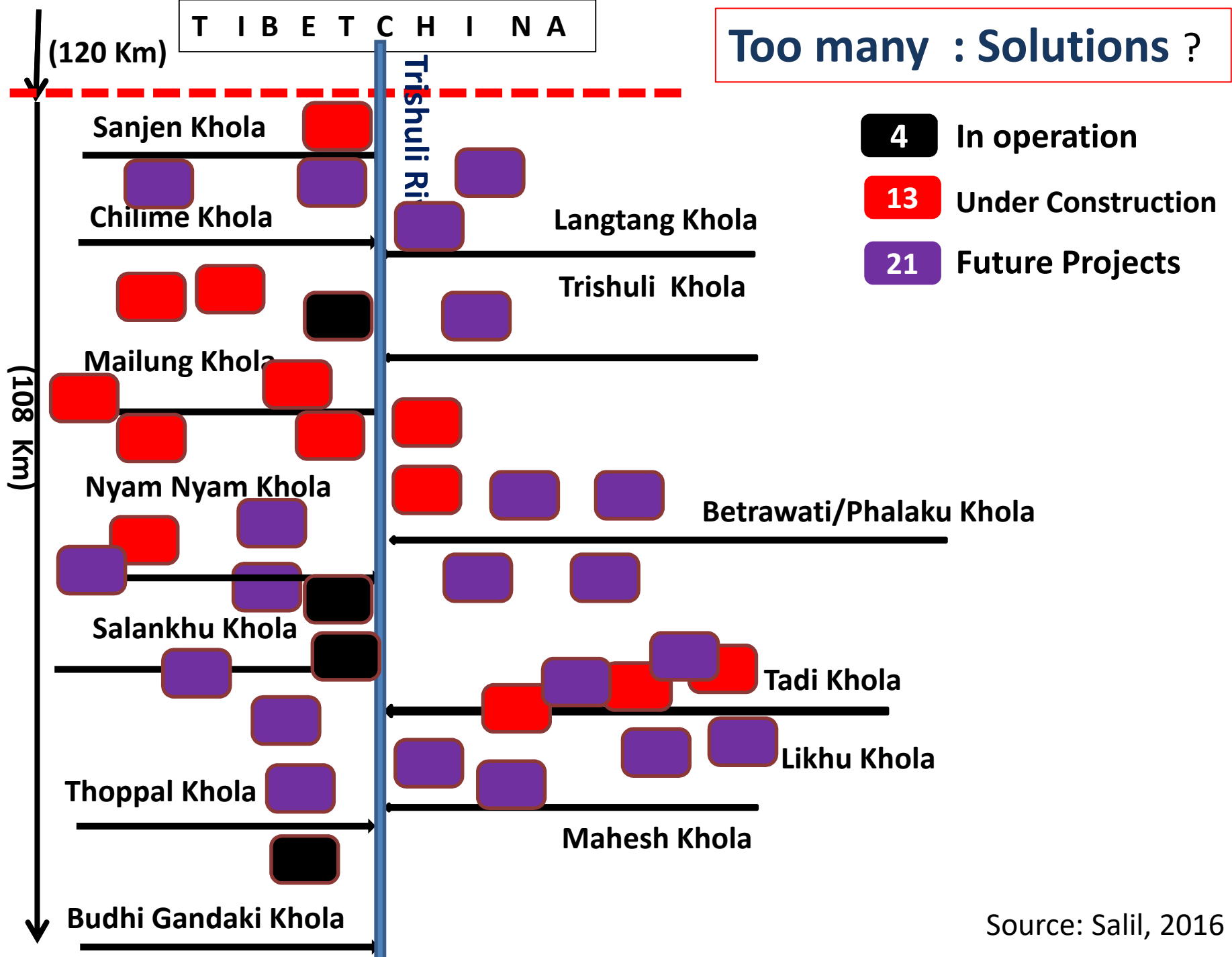
- Higher fish species abundance, high endemism
(Gurung et al. 2016)
- Adequate discharge in dry season
- The fish ladder or hatchery are a 'legal obligation' but should be an 'ecological obligation'.
- Poor knowledge of fish biology, (jumping or not ?)
- Many fish are sluggish type
- Climate change and water discharge rates

Special Considerations : Legal Aspects

- No provision of monitoring the fish ladder functioning. Whose responsibility?
- More strict watch on e-flows & connectivity.
- Poor e-flows law enforcement
- No directives, guidance from the government on Code of Conduct except that of ALCA-2017 & hydropower guidelines

T I B E T C H I N A

Too many : Solutions ?



Source: Salil, 2016

Special Considerations : Integrated Approach

Trishuli Hydropower Water
Ways & Fisheries Research
Integrated Approach



Begnas Irrigation and Fish Farm



Gurung TB (2012), Hydro Journal

Special consideration for effective fish passages in hydro dam

- **Fish ladders are not the overall solution**
- **Hatchery of native & endemic species could be a part of the solution**
- **Special provision of head and tail waters for fisheries & aquaculture could be a part the solution**

Way Forward

What may works in Nepal for *win-win* situation for hydropower & fish biodiversity conservation and production

Role of Nepal Agricultural Research Council

Could take the lead in

- Fisheries research technology generation,
- Can research on fish behavioral pattern concerning to fish passes
- Overall monitoring of fish ladder in association with NPC, MoE with budgetary provision from the NEA or other agencies in collaboration

Conclusion

- Fishways support no connectivity due to mismatching schedule of water release, spawning, breeding & migratory urge, silt removal, maintenance etc., causing the failure. Thus should be operational throughout the year for connectivity in spring- & autumn-spawning fish species.
- There are poorly-known species with variable swimming abilities, migratory behavior & population size.
- Engineers, biologists & managers must work together.
- A guideline should be prepared applicable to Nepal Himalaya fishes & water flow dynamics.
- A high level biologist & engineers committee should be formed to monitor the fish ladder functioning & solving the problems, if any.



Thank you

For further query, please contact
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