ADVANCING SUSTAINABLE HYDROPOWER: BIODIVERSITY ASSESSMENT AND MANAGEMENT WEBINAR SERIES

INTRODUCING THE TRISHULI ASSESSMENT TOOL

February 2, 2021

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Norwegian Ministry of Foreign Affairs

Dr. Leeanne Alonso

Dr. Deep Narayan Shah

Introduction and Housekeeping

Kate Lazarus
Senior Asia ESG Advisory Lead
IFC

Agenda

19:00 - 19:05	Welcome and Housekeeping	Kate Lazarus Senior Asia ESG Advisory Lead IFC
19:05 - 19:10	Welcome remarks	Jan Erik Studsrød, Counsellor/Energy and Climate Royal Norwegian Embassy, Nepal
19:10 - 20:00	Introducing the Trishuli Assessment Tool	Leeanne Alonso Biodiversity Consultant, IFC Deep Narayan Shah Associate Professor, Tribhuvan University, Nepal
20:00 - 20:30	Q & A	Moderator: Kate Lazarus Senior Asia ESG Advisory Lead IFC

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Welcome Remarks

Jan Erik Studsrød,
Counsellor/Energy and Climate
Royal Norwegian Embassy, Nepal

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Introducing the Trishuli Assessment Tool

Presenters:

Leeanne Alonso

Biodiversity Consultant, IFC

leeannealonso@yahoo.com

Deep Narayan Shah

Assistant Professor

Tribhuvan University, Nepal

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Outline of the Presentation

- What is the Trishuli Assessment Tool
- Need for the Trishuli Assessment Tool
- Development of the Trishuli Assessment Tool
- Field Methods of the Trishuli Assessment Tool
- Sampling Design and Data Analysis
- Next Steps for the Trishuli Assessment Tool

What is the Trishuli Assessment Tool

Trishuli Assessment Tool

Methodology for Standardized Sampling of Aquatic Biodiversity to Monitor Population Trends over Time

To be used to:

- Establish an Aquatic Biodiversity Baseline for ESIA
- Collect data for Environmental Flows (EFlows) Assessment
- Monitor the the impacts of Hydropower (or other impacts) on Aquatic Biodiversity

Need for the Trishuli Assessment Tool

Why is the Trishuli Assessment Tool needed?

- Paucity of data on aquatic biodiversity in Nepal
- Lack of efficient, practical and cost effective list of methods
- Availability of required equipment
- Use of different methods in different ESIA surveys- results incomparable and inconsistent
- Sampling sites and effort for ESIAs are variable and usually minimum

✓ **To meet international standards, for science and lenders (No Net Loss)**
✓ **Importance of Aquatic Biodiversity Data for ESIA and monitoring**

Why is the Trishuli Assessment Tool needed?

World Bank study of 50 operating Hydropower projects in Nepal (2020) found that:

- Most HPPs that began operation before 2000 AD have not done any environment impact studies (IEE/EIA) and thus have no mitigation measures in place
- The aquatic biodiversity mitigation measures committed in the IEE/EIA report are not generally implemented
- Lack of aquatic biodiversity monitoring by any HPP in Nepal
- A strong aquatic biodiversity baseline is needed to develop and promote biodiversity mitigation

✓ **Environmental Flows (EFlows): Only 3 of the 50 HPPs release EFlows during the dry season**
✓ **Aquatic Habitat: None of the HPPs have carried out any aquatic habitat mitigation**
✓ **Fish Migration: Among the 50 HPPs surveyed, 12 HPPs (24%) have constructed fish ladders but only 1 has been monitored (Khimti HPP)**

Development of the Trishuli Assessment Tool

Trishuli River Basin

IFC has interest in the Trishuli River Basin in Nepal due to funding of the Upper Trishuli – 1 HPP

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Cumulative Impact Assessment and Management:

HYDROPOWER DEVELOPMENT IN THE TRISHULI RIVER BASIN, NEPAL

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https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_report_cia-trishuli

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Fish Studies in the Trishuli Basin

- 60 species of fish reported for the basin (Rajbanshi 2002)
- Additional field research by NESS (2012, 2013, and 2014-2016) and SWECO (2016) for Upper Trishuli-1 HPP ESIA: 7-8 species recorded per survey
- Sampling for Cumulative Impact Assessment at 7 sites in the basin (2018), including eDNA
  25 species recorded by eDNA

Golden Mahaseer, *Tor putitora*

Common Snow Trout, *Schizothorax richardsonii*

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Other fish species from the Trishuli River Basin

Our Shared Goal for Trishuli River and other Nepal rivers:

Sustainable Hydropower Development that maintains a Healthy Aquatic Ecosystem and Biodiversity

To meet this Goal, we need to:

1) Obtain a Better Understanding of the Aquatic Ecosystem and Biodiversity, and

2) Follow up with Long-term monitoring of the status of the Aquatic Ecosystem

Considerations

Balancing between the Best Methods and Practicalities – It is Possible!

- **Requirements:** Nepal ESIA, International Lenders' Standards
- **Time**: Developer's timelines, pre-construction baseline
- **Cost**: Personnel, travel, equipment, data analysis
- **Expertise/knowledge**: Training, experience
- **Equipment**: Availability, maintenance
- **Permits:** Research, specimen collections, protected areas, electrofishing
- **Safety:** Access to sampling sites, equipment

Trishuli Assessment Tool Workshop
November 2019

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Workshop Participants

International fish researchers with expertise in fish sampling and monitoring

Nepalese fish researchers with expertise in sampling Nepali rivers and habitats

Hydropower project staff with expertise in Trishuli River environment and HPP design

Government departments staff with expertise in regulations, monitoring, EIAs

Workshop Participants

1. Dr. David Philipp, Trishuli consulting team
2. Julie Claussen, Trishuli consulting team
3. Bill Beaumont, Trishuli consulting team
4. Adrian Pinder, Trishuli consulting team
5. Gina Walsh, Trishuli consulting team
6. Adarsh Man Sherchan, Center for Molecular Dynamics Nepal (CMDN)
7. Dibesh Karmacharya, Center for Molecular Dynamics Nepal (CMDN)
8. Nikita Pradhan, Center for Molecular Dynamics Nepal (CMDN)
9. Raj Kapur Napit, Nepal Environmental and Social Services (NESS)
10. Rakesh Yadav, Nepal Environmental and Social Services (NESS)
11. Dr. Deep Narayan Shah, Central Department of Environmental Science, Tribhuvan University
12. Dr. Ram Devi Tachamo Shah, Aquatic Ecology Centre, Kathmandu University
13. Dr. Subohd Sharma, Kathmandu University
14. Dr. Bibhuti Ranjan Jha, Kathmandu University
15. Suresh Wagle, United States Agency for International Development (USAID) Paani Program
16. Asha Raymajhi, National Fisheries Research Centre (NFRC), MA&LD
17. Anjana Shrestha, National Fisheries Research Centre (NFRC), MA&LD
18. Dr. Tek Gurung, National Agricultural Research Center Council (NARC)
19. Janak Kumar Jha, Water and Energy Commission Secretariat (WECS)
20. Milan Dhungana, Ministry of Forest and Environment (MoFE)
21. Nurendra Aryal, Nepal Department of National Parks and Wildlife Conservation, MoFE
22. Tara Datt Bhatt, Nepal Energy Authority (NEA) Training Center, Kharipati
23. Prakash Gaudel, Environmental and Social Studies Department, NEA
24. Baburaja Maharjan, Trishuli HPP (NEA)
25. Ashok Baniya, NWEDC Upper Trishuli – 1 (UT-1) HPP
26. Auras Bhandari, NWEDC Upper Trishuli – 1 (UT-1) HPP
27. Shankar Pyakurel, Upper Trishuli – 3B (UT-3B) HPP (Trishuli hydropower Company)
28. Umesh Pathak, Upper Sanjen HPP
29. Rabindra Timilsina, Swet Ganga Hydropower & Construction Ltd.
30. Dr. Leeanne Alonso, International Finance Corporation (IFC)
31. Mark Pedersen, International Finance Corporation (IFC)

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Goals of the Trishuli Assessment Tool Workshop

Evaluate Field Methods for Sampling Aquatic Biodiversity

Develop a Robust Standardized Methodology for sampling fish and macroinvertebrates

- For ESIA baselines and Long-term monitoring
- = Trishuli Assessment Tool

Standardized Methodology for monitoring fish

- Adult migrations (where are they moving?) (Webinar March 16)
- Fish ladder efficiency (Webinars March 16 and April 6)

Targets for Data Collection with the Trishuli Assessment Tool

1. **Overall Aquatic Biodiversity**

    Composition (species list)

    # species

    # individuals of selected species

2**. Snow Trout adults and juveniles (*Schizothorax richardsonii*)**

    # individuals

    Distribution/locations

    Size/weight/gender/reproductive status

3. **Golden Mahaseer adults and juveniles (*Tor putitora*)**

    # individuals

    Distribution/locations

    Size/weight/gender/reproductive status

4. **Macroinvertebrates and Periphyton**

    # Key Taxa

    Functional Groups/ Key Indices

Field methods evaluated at workshop

1. Backpack electrofishing
2. Boat/Raft electrofishing
3. Gill Nets
4. Seine Nets
5. Dip Nets
6. Cast Nets
7. Traps – Baited
8. Trot Lines - Baited
9. Bamboo Traps
10. Underwater video (Go-Pro Camera)
11. Angling
12. eDNA
13. Macroinvertebrate sampling
14. Periphyton sampling

Evaluated field methods according to:

Targets

- Biodiversity (overall biodiversity)
- Snow Trout (adults, juveniles, movement)
- Golden Mahseer (adults, juveniles, movement)
- Macroinvertebrates and Periphyton

River Habitat/Location

- Tributaries (Large and small)
- Main River Channel
- Upstream and Downstream of Hydropower project
- Altered Environments (e.g. HPP reservoir, diversion reach)

Sampling design and data metrics

Working Groups

Evaluation of Field Methods for Fish

SAMPLING Methodology

Tributaries

RA - Relative Abundance and P/A = Presence /Absence

	Back Pack Electrofishing	Raft Electrofishing	Gill Nets	Trap Nets (Baited)	Seines	Trot Lines (Baited/Snares)	Dip Nets	Visual	eDNA	Angling tear
Sampling Targets										
Biodiversity	*** Excellent in all various habitats	*Not possible	*limited to shoreline area, but damaging to fish	*Not possible	*** Kick seines excellent in all shallow habitats	* Biased sampling, carnivorous only	*** only samples fry, restrcited to shallows	*** Excellent for snorkle surveys and go-pros	*** Excellent for P/A information	* Very low C biased to la
Mahseer - Adult- RA	* Success unlikely	*Not possible	*Not possible	*Not possible	*Success unlikely	*Success unlikely	*Not possible	*Success unlikely	*** Excellent for P/A , but cant distinguish adult vs juveniles	*Success ur
Mahseer - Adult Movement	*Not possible	*Not possible	*Not possible	*Not possible	*Not possible	*Not possible	*Not possible	*Not possible	*Not possible	*Not possib
Mahseer Juvenile - RA	** Probably excellent in all various habitats	* Not possible	* limited to shoreline area, but damaging to fish	*Not possible	*** Kick seines excellent in all shallow habitats	*Success unlikely	*** only samples fry, restrcited to shallows	*** Excellent for snorkle surveys and go-pros	*** Excellent for P/A , but cant distinguish adult vs juveniles	*Not possib
Snow Trout - Adult- RA	* Only potentially accessible	*Not possible	*Not possible	*Not possible	* only potentially accessible	*Success unlikely	*Not possible	*Success unlikely	*** Excellent for P/A , but cant distinguish adult vs juveniles	*Success ur
Snow Trout - Adult Movement	*Not possible	*Not possible	*Not possible	*Not possible	*Not possible	*Not possible	*Not possible	*Not possible	*Not possible	*Not possib
Snow Trout Juvenile - RA	** Limited to shoreline, shallows/riffles only	* Not possible	* limited to shoreline area, but damaging to fish	*Not possible	*** Kick seines excellent in all shallow habitats	* Success unlikely	*** only samples fry, restrcited to shallows	*** Excellent for snorkle surveys and go-pros	*** Excellent for P/A , but cant distinguish adult vs juveniles	*Not possib
Specific Details										
Relative cost	** Initial high purchase cost, low maintenance	** Initial high purchase cost, low maintenance	*** Low Cost	*** Low Cost	*** Low Cost	*** Low Cost	*** Low Cost	*** Low Cost	* Medium sampling, high lab costs	** Medium equipment
	** 2	* 3-4	*** 1-2	*** 1-2 person	** 2-3	*** 1-2	*** 1-2	*** 1-2	* 3-4	* 4-5

Trishuli Assessment Tool Field Methods

Field methods evaluated at workshop:

1. Backpack electrofishing
2. Boat/Raft electrofishing
3. Gill Nets
4. Seine Nets
5. Dip Nets
6. Cast Nets
7. Traps – Baited
8. Trot Lines - Baited
9. Bamboo Traps
10. Underwater Video (Go-Pro)
11. Angling
12. eDNA
13. Macroinvertebrate sampling
14. Periphyton sampling

Field methods selected for Tool:

- Backpack Electrofishing
- Cast Nets
- Dip Nets
- Underwater Video (Go-Pro camera)
- eDNA
- Macroinvertebrate Sampling
- Periphyton Sampling

Trishuli Assessment Tool Field Methods

Backpack Electrofishing

Cast Net

Dip Net

Visual Asessment with Underwater Camera

Environmental DNA

Macroinvertebrate and Periphyton Sampling

Trishuli Assessment Tool field methods

TARGET	TRIBUTARIES	MAINSTEM
Aquatic Biodiversity	1) Macroinvertebrates & Periphyton (Kathmandu University protocol) 2) Fish • eDNA • Backpack electrofishing • Cast nets • Underwater video • Dip nets	1) Macroinvertebrates & Periphyton (Kathmandu University protocol) 2) Fish • eDNA Limited: • Backpack electrofishing • Underwater video • Cast Nets • Dip nets

Trishuli Assessment Tool field methods

TARGET	TRIBUTARIES	MAINSTEM
Mahseer (Adult)	• eDNA • Backpack electrofishing • Cast nets	• Angling • eDNA
Mahseer (Juvenile)	• eDNA • Backpack electrofishing • Cast nets • Underwater video • Dip nets	• eDNA Limited: • Backpack electrofishing • Cast nets • Underwater video • Dip nets
Snow Trout (Adult)	• eDNA • Backpack electrofishing • Cast nets • Underwater video	• eDNA Limited: • Backpack electrofishing • Cast nets
Snow Trout (Juvenile)	• eDNA • Backpack electrofishing • Cast netting • Underwater video • Dip nets	• eDNA Limited: • Backpack electrofishing • Cast nets • Underwater video • Dip nets

Sampling Effort for each Field Method - Standardized

Method	Effort Units	Number of units	Approx. Sampling/ Total Time *RECORD THE TIME SPENT SAMPLING	Personnel
Electrofishing	Time sampling with current on (minutes)	20 min US/20 min DS (40 minutes total/site)	40 min/120 min	3 people
Cast Net	Cast Net Throws Time for 25 throws (mins)	12 US/1 MP/12 DS (25 total/site)	60 min/120 min	2 people
Dip Net	Dip Net Emersions	10 samples/site	30 min/60 min	1 person
Underwater Video	Camera sets	5 minute recording/set 6 sets US / 6 sets DS (12 sets/site)	60 min/90 min	1 person
eDNA	2 L water samples	5 samples+1 control/site (6 samples/site)	60 min/180 min	2-4 people
Macroinvertebrate sampling	Net subsamples	20 total over different substrate types	60 min/150 min	2-3 people
Periphyton sampling	Rock Scraped	5 per site	15 min/30 min	2-3 people

Trishuli Field Team February 2020

Sampling Sites for Trishuli Assessment Tool Test survey, February 2020

FIGURE LEGEND

- Hydropower Main Channel of the Trishuli River - Existing or under construction
- Hydropower Main Channel of the Trishuli River – Planned
- Hydropower Tributary of the Trishuli River – Both existing and planned
- Sampling site with Site Number – Location within Langtang National Park
- Sampling site with Site Number – Location outside Langtang National Park

SAMPLING SITES

1. Tadi Khola
2. Mailung Khola
3. Lower Chilime
4. Langtang Khola
5. Upper Budi Kosi
6. Upper Trishuli River
7. UT-3 Dewatered Zone
8. Salankhu Khola
9. Below Trishuli Dam
10. Upper Chilime
11. Budi Gandhaki Nadi
12. Juddhi Khola
13. Marsyangdi Nadi

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Field Testing of the Trishuli Assessment Tool – February 2020

Fish identification and measurements

eDNA

Electrofishing

Electrofishing Training

Macroinvertebrate Training

Baited Traps

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Comparison of Fish data during February 2020 field survey

Site #	Site Code	Site Location	Cast Netting				ElectroFisher			
Site #	Code	Site	Total # Fish	CPUE	Sample Time (min)	# Spp	Total # Fish	CPUE	Sample Time (min)	# Spp
1	TAD	Tadi Khola	20	21.1	57	4	106	199	32	15
2	MAI	Mailung Khola	26	34.7	445	1	44	75.4	35	4
3	LCH	Lower Chilime	22	24	55	1	80	320	15	2
8	SAK	Salankhu Khola	5	11.5	26	3	99	175	34	7

Field Methods of the Trishuli Assessment Tool

Backpack Electrofishing

Webinar February 4
Bill Beaumont

Electrofishing Benefits

- Extremely effective in sampling large numbers and high levels of species/size diversity
- Requires little time for actual in-water sampling
- Can sample in shallow water (slow or fast) effectively
- Can sample in very complex, rocky habitats very effectively

Electrofishing challenges

Requires:

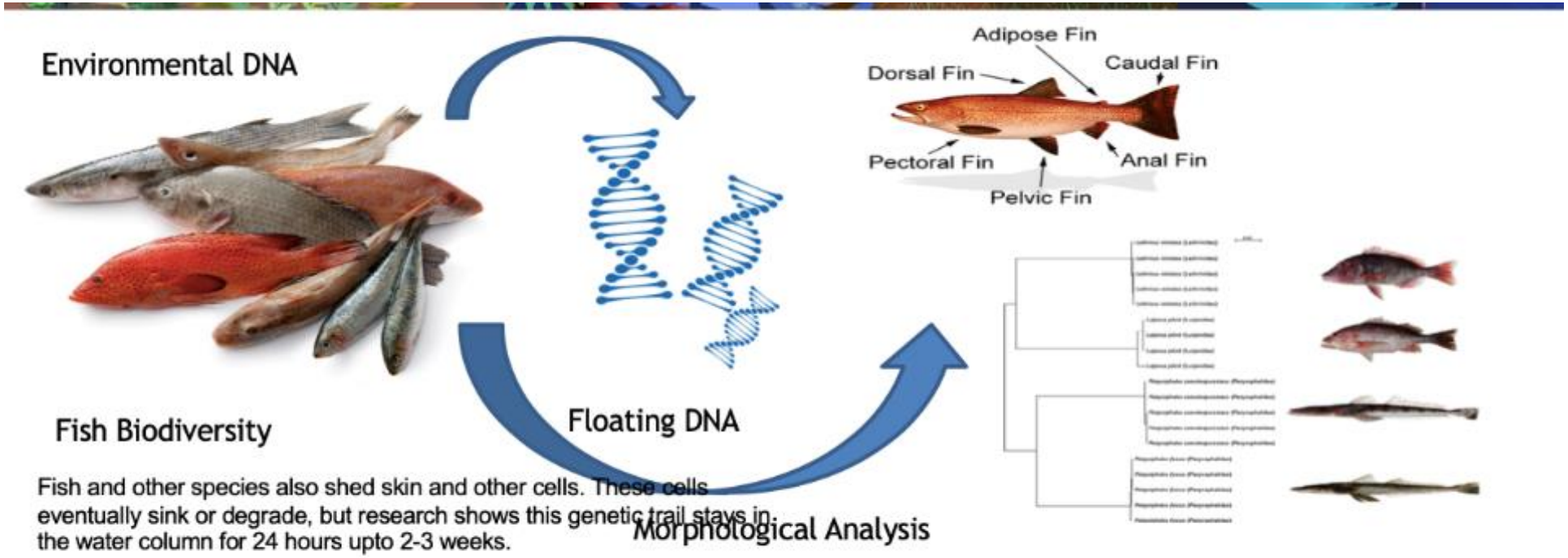
- Specialized and expensive backpack equipment ($3-10K)
- Training and practice to use effectively
- Heavy equipment
- 3 person team
- Safety precautions
- Special permits
- Shallow and clear water (tributaries and backwater, side channels)

Environmental DNA (eDNA)

Webinar February 9
Kat Bruce (NatureMetrics)
Dibesh Karmacharya (CMDN)

Nepal Fish Biodiversity Project (http://fish.org.np)

CENTER FOR MOLECULAR DYNAMICS - NEPAL



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Environmental DNA (eDNA) Benefits

- Is highly effective in detecting presence of high numbers of species
- Can detect the presence of species that are very difficult to collect with other methods
- Can be employed in essentially any water conditions
- DNA samples can be kept long term in correct storage conditions for future reference studies
- DNA samples can be used to target species other than fish

Environmental DNA (eDNA) Challenges

Requires:

- The method is still in a developing phase; some anomalies still need scientific validation
- Specific and bulky field equipment/supplies
- Specialized Training
- Expensive laboratory analysis
- Team of 3-4 people at a minimum

Limitations:

- Abundance data questionable (but improving)
- False positives are possible
- Requires substantial time to get final results

Cast Nets

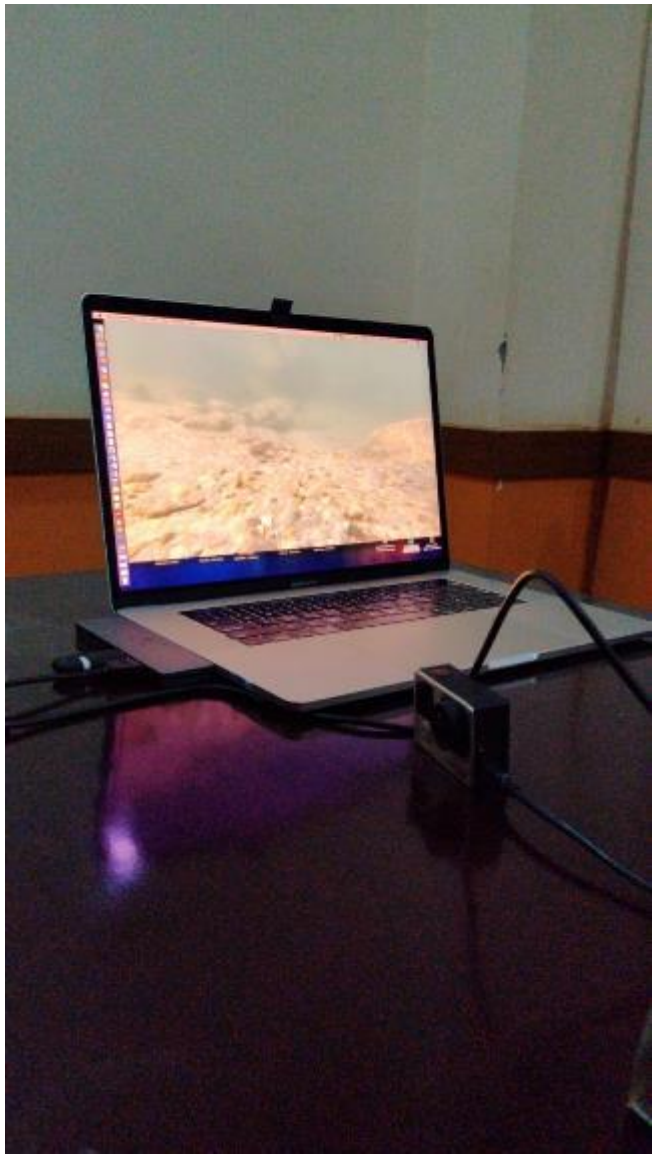
Pros:

- Moderately effective for catching fish of all sizes
- Can be used in many different habitats including deep and fast moving water
- Requires only two people (caster and bucket carrier)
- Cast nets are relatively inexpensive and available in Nepal
- Is the technique most used in the past, so most compatible with previous data

Challenges:

- Requires skill and experience to cast the net well (but local fishermen are good)
- Limited efficacy for sampling small benthic species (e.g., loach spp)
- Inconsistent mesh size between studies

Underwater Video (with Go-Pro Camera)



Underwater Video

Pros:

- Can observe many fish and often species not captured with other gear
- Requires only one operator (subject to Health and Safety regulations)
- Training is minimal
- Provides permanent record

Challenges:

- Equipment is somewhat expensive
- Data analysis requires lab-based viewing to count and ID fish
- Requires very clear water
- Deployment and retrieval of equipment may require swimming

Dip Nets

Pros:

- Equipment is inexpensive and easy to use
- Requires little time for actual in-water sampling
- Only reliable method for capturing larval fish
- Requires only a single operator
- Provides evidence of species recruitment and identifies spawning/nursery areas

Challenges:

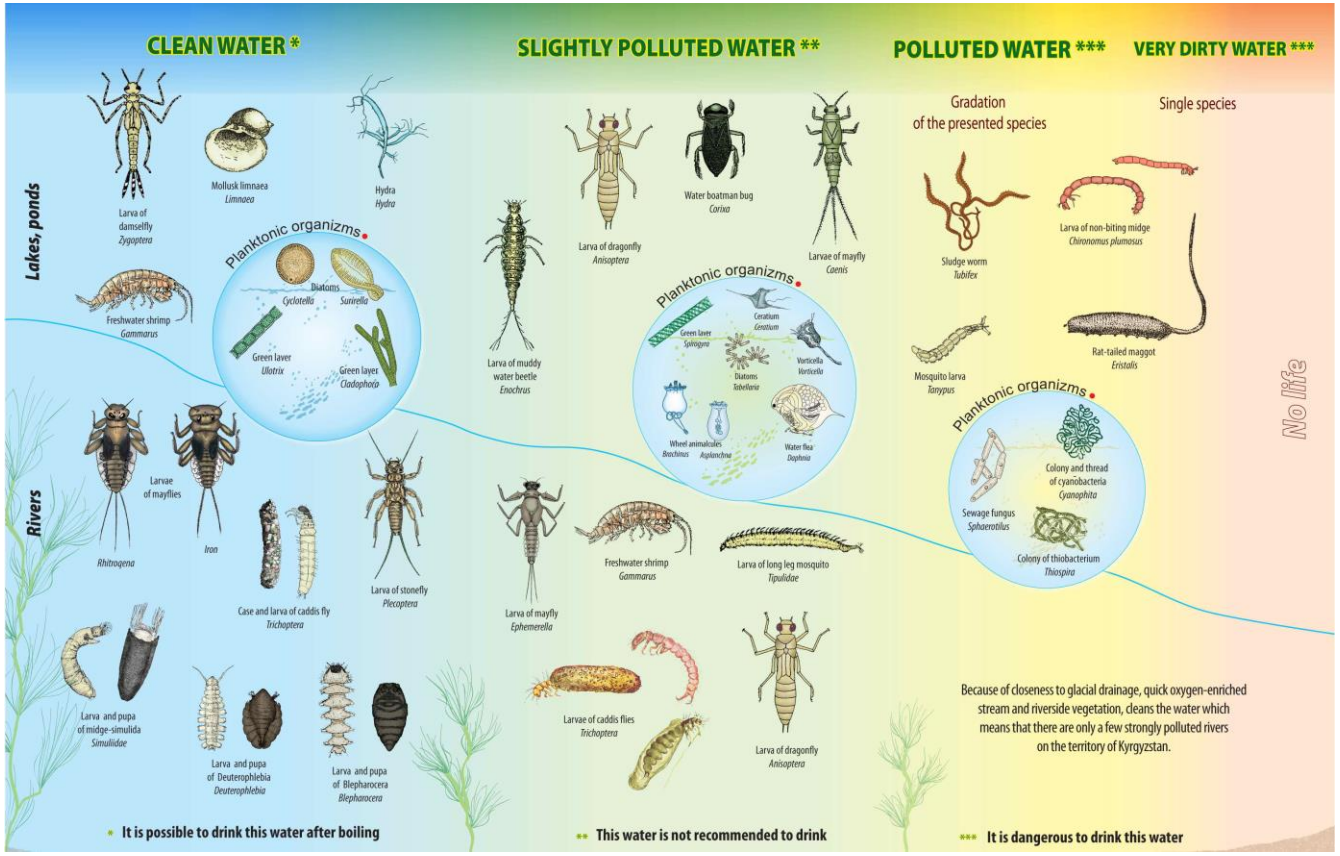
- Requires spotting larval fish visually in shallow water
- Is extremely size selective
- Requires shallow and clear water

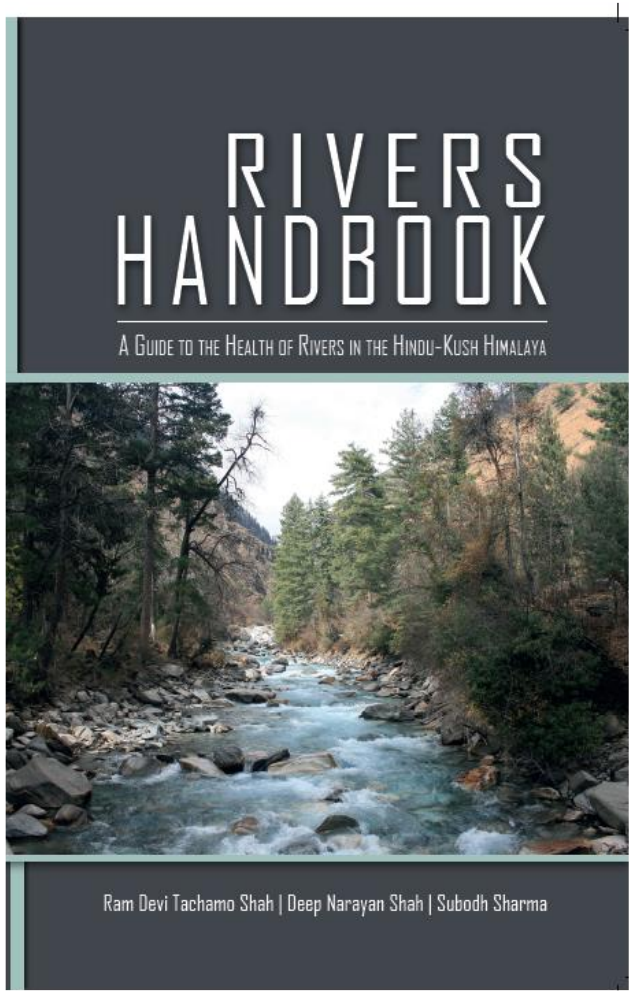
Macroinvertebrates and Periphyton

Webinar February 11

Ram Devi Tachamo Shah
Deep Narayan Shah

- Macroinvertebrates are aquatic invertebrates larger than 500 um
- Periphyton are small aquatic animals and plants (eg. algae) that cling to rocks
- Both are important in the aquatic ecosystem
  - Food for many other organisms, especially fish
  - Break down organic matter
  - Filter and clean the water
- Respond quickly to environmental changes, so are good indicators





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Macroinvertebrates and Periphyton

Pros:

- Occur in high abundances -*relatively easy to sample*
- Relatively larger body size -*easier to identify*
- Taxonomically and ecologically highly diverse
- Live from few months to years -*integrate short- and long term pollution exposures*
- Limited mobility -*preventing them from escaping from occasional pollutions*
- Many taxa are highly sensitive to changes in water quality, water level fluctuations and habitat changes

Macroinvertebrates occupy the largest portion of aquatic food web and form a vital link between aquatic plants, algae, and leaf litter to the fish species and even birds.

Challenges:

- Requires high degree of standardisation of the methods and assessment and evaluation of effects

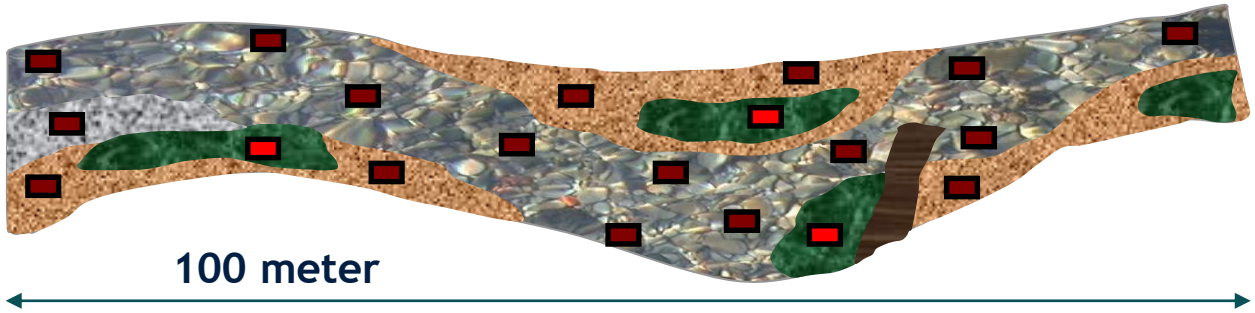
Sampling Design and Data Analysis

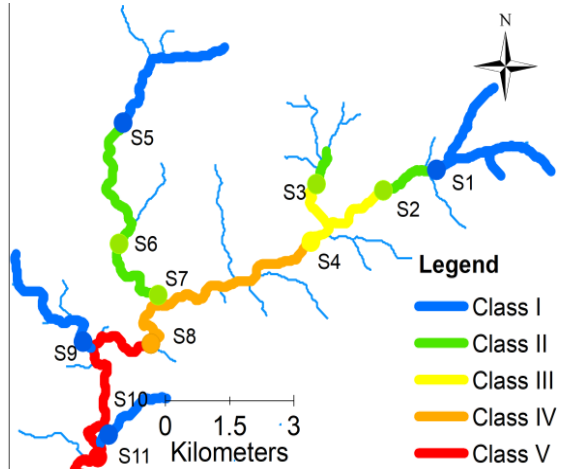
February 18 Webinar
Leeanne Alonso (IFC)
Jonathan Levin (RSA)

Multi-habitat Sampling (MHS)

- ✓ representative sampling of all major habitats (mineral and organic)

Requirements: Field protocol, habitat estimation sheets, kick-nets, gloves, waders, buckets, white trays, sample containers, jars, vials, sieve (500 µm), ethyl alcohol (99 %), pencil & labels, paper, life jacket, rope, second person(!), cellular phone…





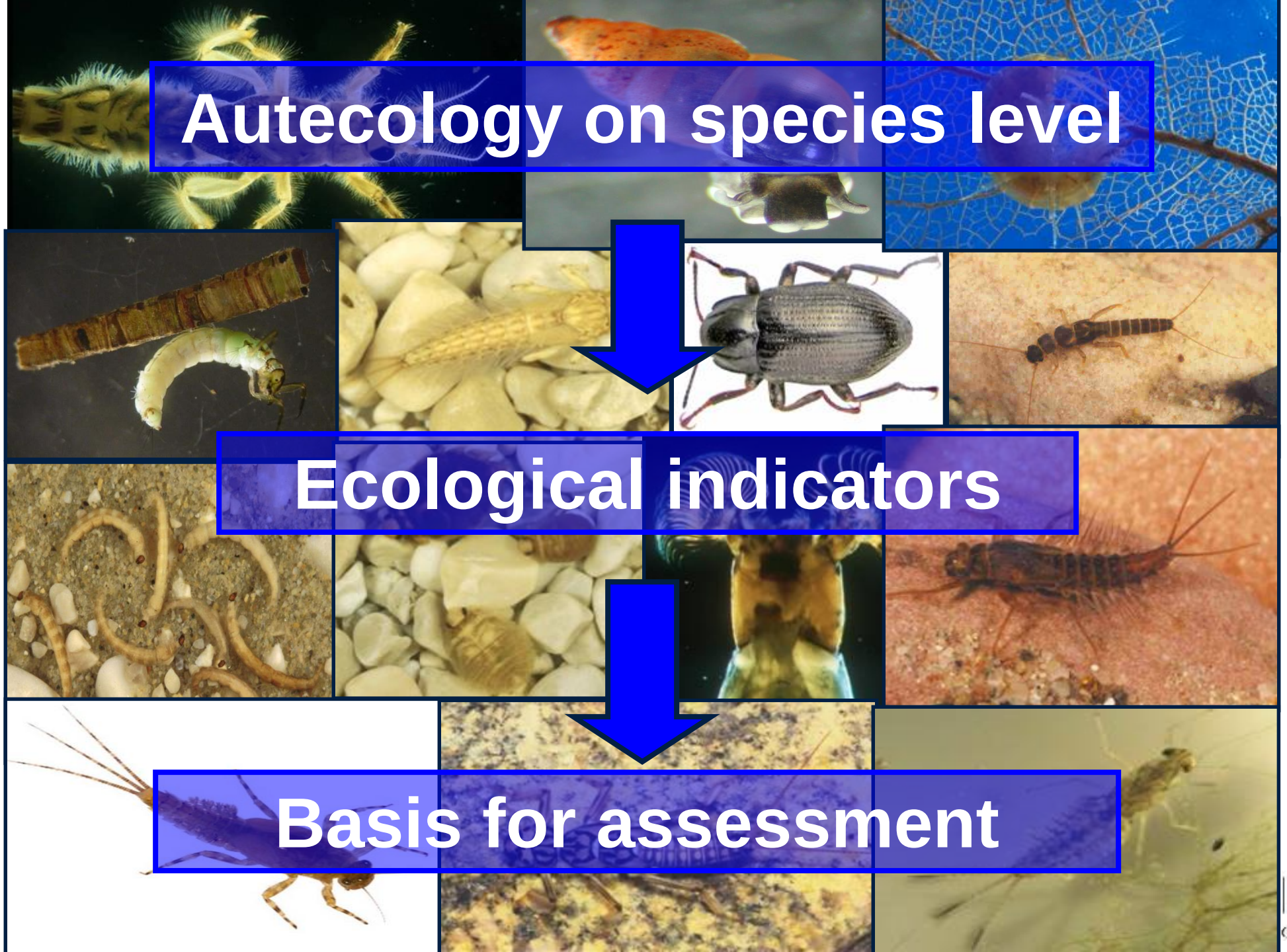
I
High

II
Good

III
Moderate

IV
Poor

V
Bad



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Data Analysis: Macroinvertebrates

Metric type	Candidate metrics	Calculation
Richness measures	EPT richness	Number of present Ephemeroptera, Plecoptera and Trichoptera taxa
	Shannon-Wiener diversity index (H')	$-\Sigma p_i \ln p_i$ (Shannon and Weaver, 1949) Where, S=taxa richness, p_i=relative abundance of i^{th} taxa
Composition measures	% EPT richness	Percentage of Ephemeroptera, Plecoptera and Trichoptera taxa
	% Sensitiveindividuals	Percentage of present taxa individuals with tolerance score ≥ 7
	% Facultative individuals	Percentage of present taxa individuals with tolerance score 4 to 6
	% Tolerant individuals	Percentage of present taxa individuals with tolerance score 1 to 3
	Biotic Index	$\boldsymbol{Biotic\ Index} = \sum_{i=1}^{n} \boldsymbol{TSSi/n}$ Where, TTS_i is the Taxa Sensitive Score of taxon *i* and *n* is the total number of scored taxa
Functional Feeding Guilds	% Shredder individuals	Percentage of Shredder individuals
	% Scraper individuals	Percentage of Scraper individuals
	% Collector-gatherer individuals	Percentage of Collecter-gatherer individuals
	% Collector-filterer individuals	Percentage of Collector-filterer individuals

Data Targets

1. **Overall Aquatic Biodiversity**

   Composition – List of Species with taxonomically correct names

   # species

   # individuals of selected species

2. **Snow Trout adults and juveniles** (*Schizothorax richardsonii*)

   # individuals

   Distribution/locations

   Size/weight/gender/reproductive status

3. **Golden Mahaseer adults and juveniles** (*Tor putitora*)

   # individuals

   Distribution/locations

   Size/weight/gender/reproductive status

4. **Macroinvertebrates/Periphyton**

   # Key Taxa

   Functional Groups/ Key Indices

Study Design and Data Analysis

Plan the Sampling Design and Data Analysis from the start to contribute to all objectives:

- Establish an Aquatic Biodiversity Baseline for ESIA
- Collect data for Environmental Flows (EFlows) Assessment
- Long-term Monitoring

Monitoring requires repeated sampling with same method, replicates, and specific data metrics

ESIA Baseline

Questions and Data

1. What is there- which species? (Composition)
   - Species List
2. How many are there? (Abundance or Population Size)
   - # individuals per species
3. Where are they? (Location and Distribution
   - Map of species distribution, compare abundance between sites

Sampling Frequency

- At least 2 seasons: Dry season and Wet season
- Preferably more in relation to fish biology and HPP operation (e.g. onset of monsoon upstream migration, spawning, low flows)

Sampling Sites

- As many as possible to capture variation in the ecosystem

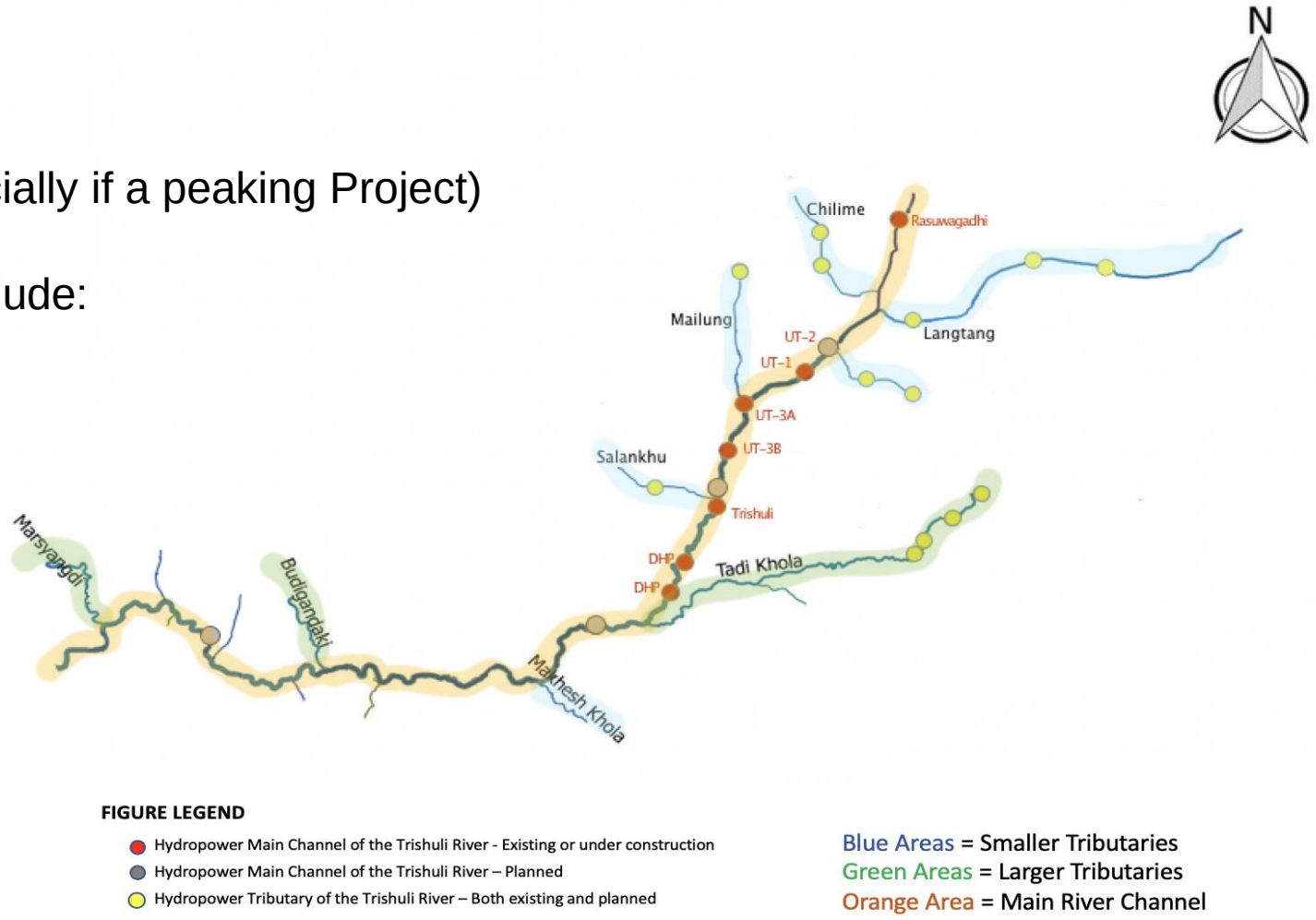
Sampling Regions

An ESIA aquatic survey should include sampling in these Sampling Regions:

1. Upstream of Hydropower Project, including reservoir area
2. Diversion reach
3. Downstream of Power House (especially if a peaking Project)

Within each region, sampling sites should include:

- Main Stem
- Large Tributaries
- Small Tributaries
- River Tributaries



Fish Data to collect in field

Fish Identification Webinar February 17
Rajeev Rahavan, KOFUS, India
Asha Rayamajhi, NFRC

TRISHULI RIVER FISH SAMPLING DATA											
Site Number	1										
River Name	**Tadi Khola**										
Location	Panchakanya										
Code	TAD	Water Temperature	17								
Date	23-Feb-20	Conductivity	62								
US Time/Distance	14min/80m	Voltage	400								
DS Time/Distance	18min/100m	Frequency (Hertz)	50							Total fish sampled = 106	
Method	EF	Duty Cycle	10%							Total species sampled = 15	
Sample #	**DnSt/UpSt**	**Species**	**SL**	**FL**	**TL**	**Wt**	**Photo**	**DNA - Fin**	**Voucher**	**Fish ID**	**NOTES**
1	DS	*Barilius Barilla*	53	57	61	1.5	N	N	N		
2	DS	*Barilius Barilla*	55	60	66	2.5	N	N	N		
3	DS	*Barilius bendelisis*	65	73	80	4.0	N	N	N		
4	DS	*Neolissochilus hexagonolepis*	69	76	87	7.5	N	N	N		
5	DS	Lateral striped minnow	66	74	85	5.5	N	N	N		
6	DS	*Barilius Barilla*	65	73	80	5.5	N	N	N		
7	DS	*Barilius Barilla*	60	67	75	4.0	N	N	N		
8	DS	*Barilius Barilla*	51	57	64	3.5	N	N	N		
9	DS	*Barilius Barilla*	50	54	62	2.0	N	N	N		
10	DS	Lateral striped minnow	54	65	69	4.0	N	N	N		Males with Milt
11	DS	*Barilius bendelisis*	88	98	108	7.5	N	N	N		
12	DS	*Barilius bendelisis*	75	82	90	8.0	N	N	N		
13	DS	*Barilius Barilla*	58	64	72	4.0	N	N	N		
14	US	*Garra spp*	136	155	169	66.0	Y	Y	N	TAD-EF-14	Female with ripe eggs
15	US	*Schizothorax spp*	122	135	151	31.0	Y	Y	N	TAD-EF-15	Tuberacles present
16	US	*Schizothorax spp*	108	120	135	21.0	N	N	N		
17	US	*Barilius bendelisis*	88	97	105	11.5	N	N	N		
18	US	*Barilius bendelisis*	70	79	86	6.5	N	N	N		
19	US	*Barilius Barilla*	65	73	80	5.5	N	N	N		

Long-term Monitoring

Questions and Data

1. How has the the number of species changed over time?
2. How has the number of individuals of target species changed over time?
3. How has the distribution of species changed over time?
4. How has the composition of species changed over time?

Monitoring analysis requires specific metrics to quantitatively compare over time

1. CPUE = Catch (# individuals) Per Unit Effort (hours)
2. SPUE = Species (# species) Per Unit Effort (hours)

Monitoring analysis requires replicates to capture natural variation

- Trishuli Assessment Tool recommends at least 6 replicates (spatial sites or temporal surveys) per sampling region

Quantitative Metrics for Long-term Monitoring

Target	Indicator	Metric
Overall Aquatic Biodiversity	Composition	Species names
	Species Richness (# species)	# species / hour (SPUE)
	Abundance of target species	# individuals / hour (CPUE)
Snow Trout adults and juveniles (*Schizothorax richardsonii*)	Abundance	# individuals / hour (CPUE)
Golden Mahaseer adults and juveniles (*Tor putitora*)	Abundance	# individuals / hour (CPUE)
Macroinvertebrates/Periphyton	Richness and abundance of key taxa	EPT Index
	Functional Feeding Groups	Ratio of groups

Sample Data from the Tadi Khola, February 2020

Metric	Electrofishing	Cast Nets	Dip Nets
Total # fish individuals (N)	106	20	30
Total Effort (hours)	0.53	0.95	0.33
CPUE (# individuals/hour)	199	21.1	90
Species Richness - Total # fish species (S)	15	4	1
SPUE (# species/hour)	28	4.2	3

- For long term monitoring, CPUE and SPUE can be compared statistically between sampling surveys using T-test, ANOVA or non-parametric statistics
- February 18 Webinar will showcase an Excel-based statistical tool designed for the Trishuli Assessment Tool

Next Steps for the Trishuli Assessment Tool

Next Steps

Trishuli Assessment Tool Kit

- Manual
- Recordings of February Webinars
- Powerpoints from February Webinars
- In-person Training Courses

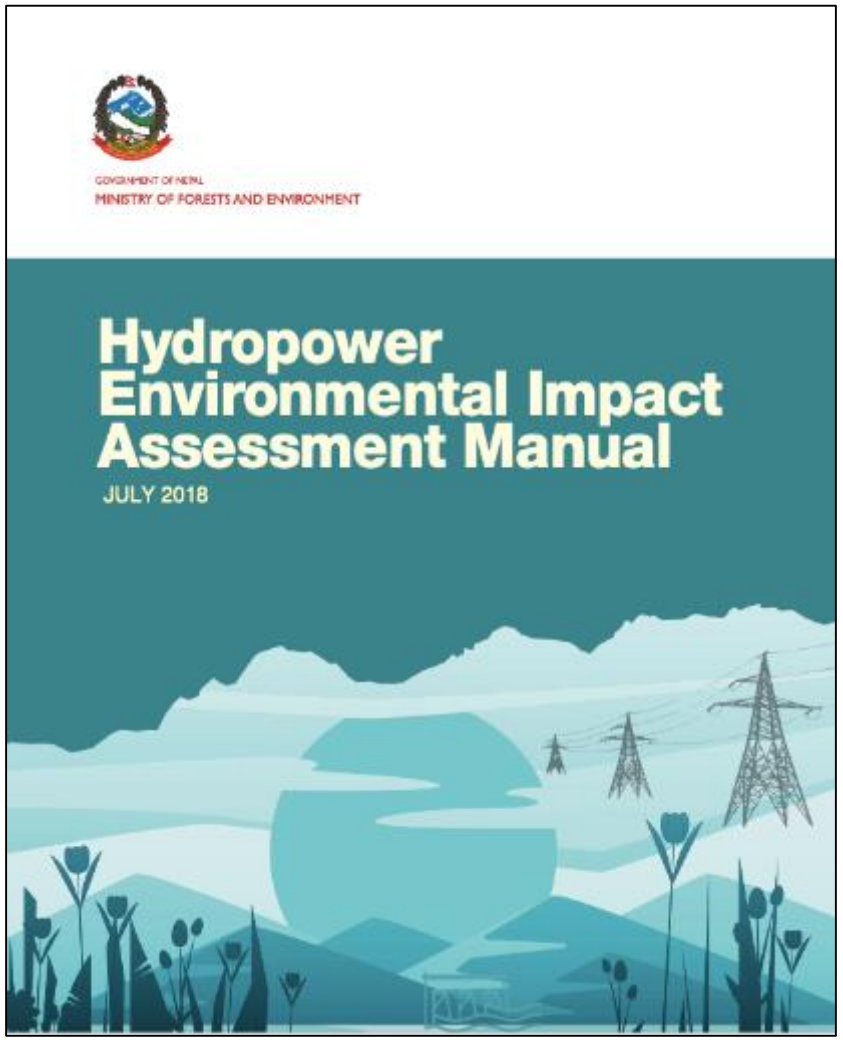
Develop local capacity for the Trishuli Assessment Tool

Promote use of the Trishuli Assessment Tool for ESIAs

- NEA
- Private Hydropower Developers

Link with the Freshwater Ecosystem Assessment Handbook

- Companion handbook to the Hydropower Environmental Impact Assessment Manual (MoFE)
- Forthcoming from ICIMOD and Forest Research Training Centre (FRTC)
- Prepared by Deep Shah and Ram Devi Tachamo Shah
- Webinar on May 11



http://mofe.gov.np/downloadfile/Hydropower%20Environmental%20Impact%20Assessment%20Manual_1537854204.pdf

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Continue to join the February IFC Workshop Webinar Series

Learn more about the field methods and other components of the Trishuli Assessment Tool:

- **February 4: Electrofishing**
- **February 9: Environmental DNA (eDNA)**
- **February 11: Macroinvertebrate Sampling**
- **February 17: Himalayan Fish Identification**
- **February 18: Data Analysis for Long-term Monitoring**

Sign up for webinars individually. Participants who attend all 6 webinars will receive a Certificate from IFC and be considered for in-person training on these topics.

Q & A Session

Moderator:

Ms. Kate Lazarus

Senior Asia ESG Lead

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Thank you

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