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COMMUNITY-BASED AQUATIC BIODIVERSITY MONITORING IN MIDDLE RAPTI AND JHIMRUK WATERSHEDS OF RAPTI RIVER BASIN

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Cover photo: Women group monitoring the aquatic biodiversity in Rapti River, Middle Rapti Watershed

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COMMUNITY-BASED AQUATIC BIODIVERSITY MONITORING IN MIDDLE RAPTI AND JHIMRUK WATERSHEDS OF RAPTI RIVER BASIN

PROGRAM TITLE:	**USAID PAANI PROGRAM**
DAI PROJECT NUMBER:	**1002810**
SPONSORING USAID OFFICE:	**USAID/NEPAL**
IDIQ NUMBER:	**AID-OAA-I-14-00014**
TASK ORDER NUMBER:	**AID-367-TO-16-00001**
CONTRACTOR:	**DAI GLOBAL LLC**
DATE OF PUBLICATION:	**JUNE 2021**
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ABBREVIATIONS

AABCA	Aquatic Animal and Aquatic Biodiversity Conservation Act
CAACG	Community Aquatic Animal Conservation Group
CBM	Community-Based Monitoring
CBR	Community Biodiversity Register
CPUE	Catch Per Unit Effort
Paani	Program for Natural Aquatic Resource Improvement
USAID	United States of America International Development

1. EXECUTIVE SUMMARY

This report presents the results of aquatic biodiversity monitoring completed by community aquatic animal conservation groups (CAACGs) in the Rapti and Jhimruk Rivers and their tributaries using a community-based monitoring (CBM) approach. CBM is a monitoring system that involves local communities and other stakeholders in data collection and interpretation to support conservation planning. It seeks to integrate local socio-ecological knowledge into long-term monitoring and planning. CBM builds awareness of natural assets, capacity in natural resource management, and local ownership.

CAACGs collected data during patrolling and monitoring activities and through focus group discussion, for which they received training by the USAID/Nepal's Paani Program. Monitoring occurred at 21 sites within delineated community-managed river stretches in the Middle Rapti and Jhimruk watersheds. Traditional fishing gear was used to sample fish, and aquatic plants, mammals and birds were visually observed. Participants discussed and confirmed the general occurrence of taxa, reoccurrence of disappeared taxa or new appearance of special taxa. Between May 2017 to September 2020, 20 CAACGs completed 38 monitoring events involving 6 - 15 CAACG members at each occurrence.

Collectively 74 fish species were identified and recorded in the Rapti and Jhimruk rivers, including the tributaries of Arkha River, Gartang River, Lung River, Dolai River and Sano Nadi. CBM recorded 29 and 39 species of fish from the main stem of Jhimruk and Rapti River. Seasonal assemblage in fish species was highest in the Jhimruk River during the summer and in the Rapti River during the winter indicated that migratory species such as Mahseer (*Tor putitora*) and Goonch (*Bagarius* spp) may contribute to species assemblage through upstream and downstream migration, respectively.

CBM of aquatic biodiversity revealed that the appearance of two new species of fish: Cheparo Machha (*Glyptothorax* sp) and Jhojho Machha in the main stem of the Jhimruk River during the wet season. Reappearance of long-absent species of turtle (Indian Roofed Turtle - *Pangshura tecta*) in Dolai River and long-range migratory fish species Mahseer (*Tor putitora*) in streams and canals joining the Rapti River in Middle Rapti Watershed indicate that aquatic habitats are gradually improving as the result of declining destructive and illegal fishing and use of responsible fishing gear and practices.

CBM identified and recorded 36 types of vascular and riparian aquatic plants and 20 species of aquatic insects in the Rapti River Basin with the highest diversity in the Rapti River. Similarly, CBM recorded eight species of mollusk, including six species of gastropods and two species of bivalve, as well as one species of crustacean (freshwater shrimp) in the basin. Two species each of freshwater carbs, amphibians and reptiles were observed in a few monitoring sites in the Jhimruk Watershed and in most sites in the Middle Rapti Watershed. Seven species of waterfowl and 30 species of terrestrial birds were observed in the monitored river stretches of Rapti and Jhimruk Rivers.

CAACGs have begun to record aquatic diversity in their designated aquatic biodiversity register (CBR) with details of species habitat and indigenous knowledge related to observed taxa and associated threats. One general weakness of CBR is that all aquatic species are recorded using local names which varied greatly from place to place. Photographs were not available of most of the observed taxa to determine standard common names. The recording ledgers designed for the monitoring activity generally had limited information the volume of fish captured, catch per unit effort (CPUE) and number taxa by categories.

CBM revealed that CAACGs have limited capacity to analyze and interpret the outcomes of community-based monitoring, and to correlate findings with river health. Translating knowledge of aquatic biodiversity into conservation planning requires CAACG to have ties to and work with the scientific community. CCAGs require ongoing technical support from fisheries officers and researchers before it can solely undertake CBM efforts. Data generated through CBM should be verified with external expertise. Despite these identified weaknesses in the community-based monitoring program, CBM does raise awareness of aquatic biodiversity in local communities and thereby can build a constituency for biodiversity conservation. In order to ensure greater community participation in the monitoring, management and conservation of aquatic biodiversity in rivers, the river stretch co-management approach should be strengthened and expanded across the Rapti River Basin.

2. INTRODUCTION

USAID/Nepal's Paani Program's overall goal is to enhance Nepal's ability to manage water resources for multiple uses and users through climate change adaptation and the conservation of freshwater biodiversity. Paani seeks to reduce threats to freshwater biodiversity and related livelihoods by reducing destructive and illegal fishing, overfishing, and invasive species. Apart from human actions, climate-induced hazards increasingly threaten the quality and quantity of water, placing further stress on freshwater biodiversity.

Freshwater biodiversity inventories can be a useful bio indicator of ecosystem status owing to their vulnerability to environmental stressors and human disturbances (Dudgeon, 2010). Information on the species composition of fish communities (i.e., the presence or absence of particular species and their distributions) can provide valuable information for protecting endangered species and vulnerable habitats (Arponen et al., 2005). This approach can also help identify invasive species (Didham et al., 2007), which can adversely affect the ecosystem.

Biodiversity and biological resource monitoring as components of sustainable management of natural resources can be utilized for attaining conservation goals (Margoluis and Salafsky, 1998). The main function of monitoring/assessment is to generate a regular (time series) supply of data and information on patterns and trends of biodiversity and biological resources as a basis for management responses to ensure that species and habitats remain in a healthy state (Teder et al., 2007). Assessment is also a means to inform policy/decision-makers and the society as a whole on the condition of the natural environment.

Monitoring can be practiced in different forms: (1) professional monitoring (usually undertaken by experts and scientists) and (2) monitoring by local communities on the basis of their local ecological knowledge systems (Bani et al., 2006; Danielsen et al., 2008). Monitoring by scientists is generally perceived to gain more attention from policy- and decision-makers who focus on larger spatial scales (e.g. national and international) and longer time spans, while community-based monitoring tends to inform decisions on local spatial scales and over shorter time spans (Danielsen et al., 2010).

Community-based monitoring is defined as a process where concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track, and respond to issues of common community concern (Fleener et al., 2004). In order to be successful, monitoring methods should be simple and well integrated within the local ecological knowledge base as well as with

daily livelihood activities. Community-based assessment is found to be sustainable over the long term, meaningful in the local context, less costly than professional method and manageable with locally available resources (Uychiaoco et al., 2005). The approach is considered to be especially suitable for the developing countries like Nepal where resources and technical capacity are often inadequate (Yoccoz et al., 2003).

Community-based monitoring (CBM) is - as already mentioned – is a simple monitoring system that involves local communities and other stakeholders not only in data collection but also in data interpretation (analysis and decision-making on the basis of the results). CBM is context-and site-specific and is developed through a participatory process with local community members and those authorities that are responsible for managing the areas. It is easily managed and cost-effective and is designed to be long-term and self-sustainable beyond the lifetime of externally supported programs. It is based on the standardized collection of selected data at regular intervals using the same approaches (e.g., well defined routes/transects surveyed by community members at regular intervals). The data should be easy to obtain in the field with no or a minimum of equipment necessary, be as easy as possible to store, and be comparable and simple enough to allow for quick and clear interpretation.

In the Rapti River Basin, owing to its importance for fisheries as well as for conservation, USAID Paani Program has supported community-based monitoring program in Middle Rapti and Jhimruk Watersheds. Monitoring focused on biological and fisheries resources. The immediate objective of the assessment is to protect the river biodiversity and to conserve its biological resources, which are under severe threat from overfishing, destructive fishing, urbanization, waste disposal and agricultural runoff. This report describes the community engagement in biodiversity assessments in the Rapti River, the results of the monitoring efforts, and learning from these CBM initiative.

3. OBJECTIVES

The overall objective of community-based aquatic biodiversity initiatives is to engage communities in long-term monitoring of aquatic biodiversity of designated river stretches based on local socio-ecological knowledge to substantiate conservation efforts. The specific objectives are to:

- Engage the community in the conservation of freshwater biodiversity;
- Encourage the participation of the local community other stakeholders in biodiversity monitoring, management and protection;
- Build the capabilities of communities to identify changes in the biological resources of the areas that they manage;
- Gather information on biodiversity in the respective river/river stretch; and,
- Support sustainable long-term aquatic biodiversity conservation through local community support.

4. METHODOLOGY

The community-based aquatic biodiversity monitoring program was conceptualized and launched by the Paani Program. Initially, the program supported the development and passage of Aquatic Animal &

Aquatic Biodiversity Conservation Act (AABCA) which gave Community Aquatic Animal Conservation groups (CAACGs) rights and responsibilities to sustainably manage, develop and conserve local river stretches. CAACGs members participated in CBM efforts.

Prior to the CAACG's beginning to be established in 2018, local residents were not involved in systematic biodiversity monitoring. The AABCA gave CAACGs the mandate to conduct such monitoring as part of their requirement to use and manage the river stretch in an ecologically sustainable manner. CBM was used to monitor aquatic resource utilization and to detect trends in biological diversity.

The Paani Program trained CAACG members on CBM and in how to maintain a community biodiversity register. Paani conducted 13 training events for 240 members of 20 CAACGs formed in Middle Rapti and Jhimruk watersheds (Figure 1). Training participants included over 83% janjati and 57% women. The training addressed the fish gear that was permitted to be used for monitoring efforts under the AABCA.

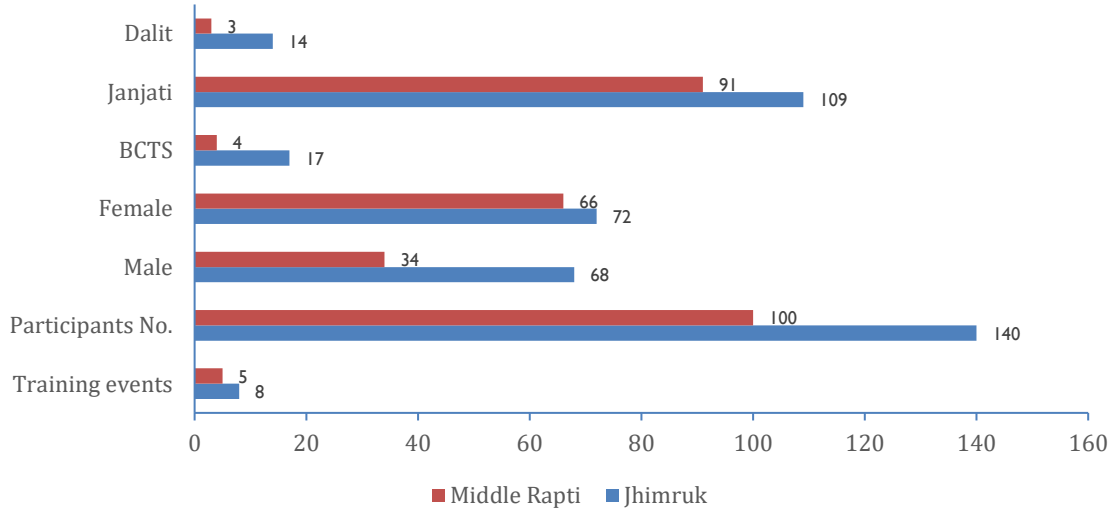

Figure 1: Number of events on aquatic biodiversity monitoring training provided to the number of community members by watershed, gender and ethnicity

CAACGs collected data during patrolling and monitoring activities and through focus group discussion, for which they received training by the USAID/Nepal's Paani Program. Monitors were CAACG members who had basic knowledge in reading and writing Nepali. It was not a requirement that all monitors be literate, but it was required that the lead monitor by literate. Monitoring sites in the Middle Rapti and Jhimruk watersheds were aligned with the presence of CAACGs and within their delineated river stretches (Figures 2 and 3). 14 sites were identified in the Jhimruk watershed and seven sites in the Middle Rapti watershed The process followed by the CAACGs is illustrated in Figure 4.

Figure 2: Monitoring sites along the Jhimruk River, Jhimruk Watershed

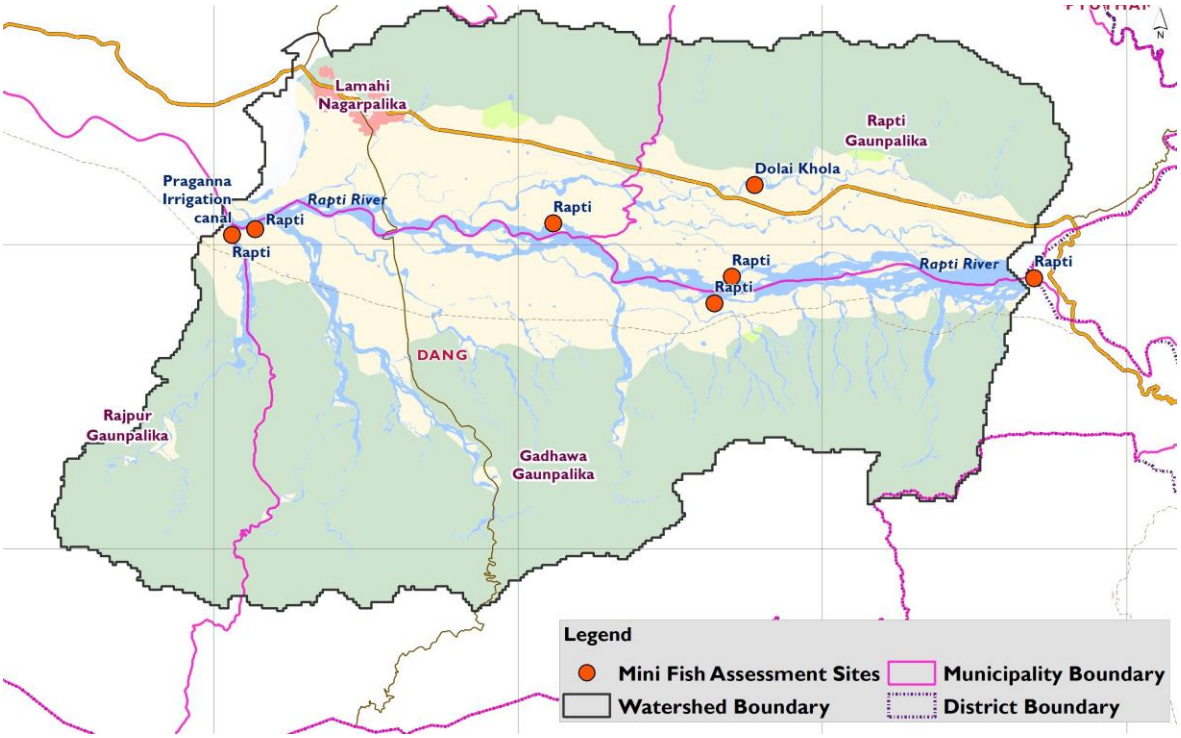

Figure 3: Number of events on aquatic biodiversity monitoring training provided to the number of community members by watershed, gender and ethnicity

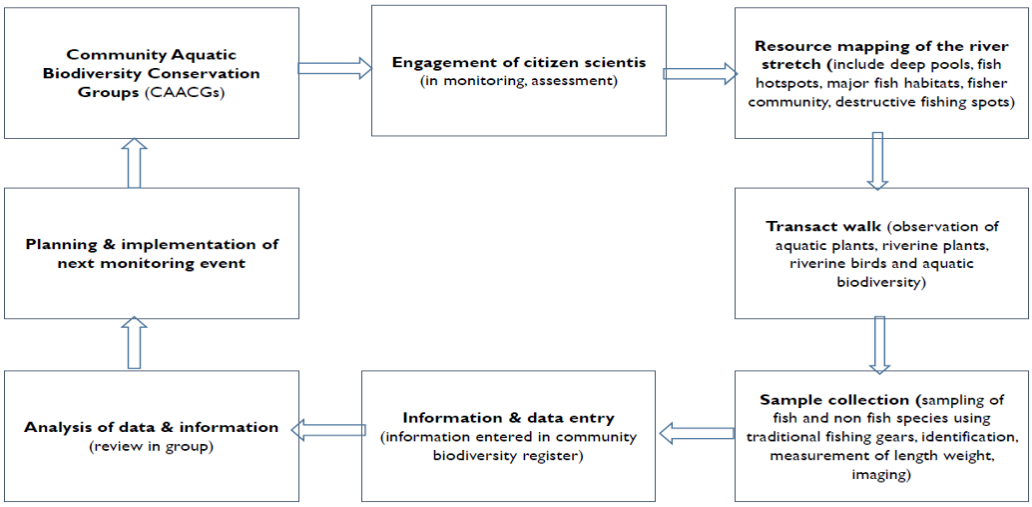

Figure 4: Flow diagram of steps in community-based aquatic biodiversity monitoring in Jhimruk and Rapti River

After river stretches were identified and trainings completed, 38 community-based aquatic biodiversity monitoring events were completed between May 2017 and September 2020. 149 members of 8 CAACGs in the Jhimruk watershed and 198 members from 12 CAACGs in the Middle Rapti watershed were engaged (see Figure 5, 6 and Table 1). Of the 347 members involved in monitoring, women comprised 68% of the monitoring team in Middle Rapti watershed and 38% in Jhimruk watershed (Figure 7). Each monitoring team ranged from 6 to 15 people.

Monitoring of aquatic biodiversity by CAACG members in Chaklaghat, Jhimruk River, Jhimruk Watershed

Monitoring teams used traditional gears – helka (deep net) and cast net – to sample fish and mollusks and visually observed aquatic plants, mammals and birds. Monitoring teams discussed their observations to confirm the general occurrence of taxa, reoccurrence of disappeared taxa or new appearance of special taxa. All information and data collected was recorded in a designated format (Annex 1). For this report, data and information obtained was processed using Microsoft Excel and analyzed using tabular and descriptive methods.

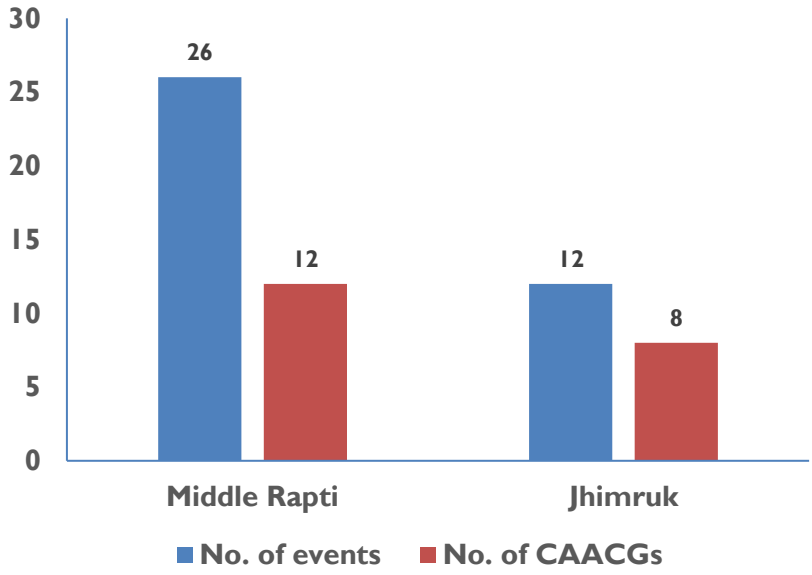

Figure 5: Number of events on community-based aquatic biodiversity monitoring conducted and the number of Community Aquatic Animal Conservation Groups (CAACGs) involved in the Middle Rapti and Jhimruk Watersheds

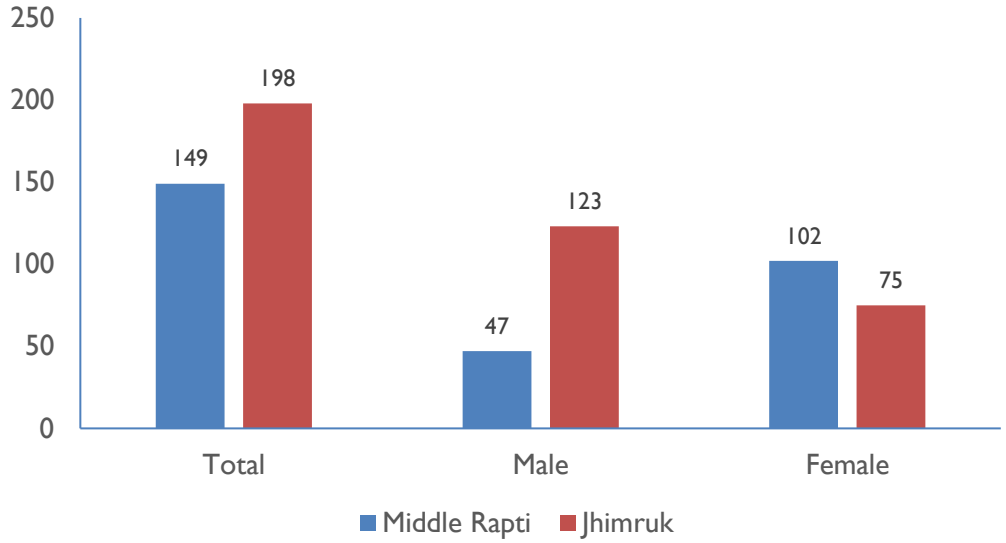

Figure 6: Number of community members involved in monitoring by gender in the Middle Rapti and Jhimruk Watersheds

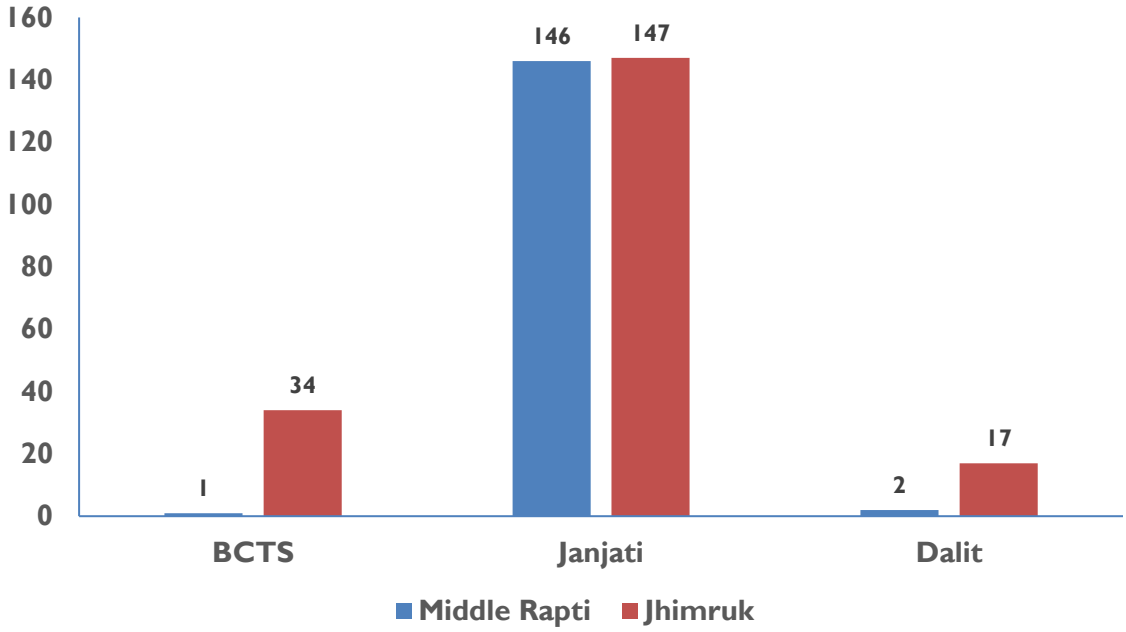

Figure 7: Number of community members involved in monitoring by ethnicity in the Middle Rapti and Jhimruk Watersheds

TABLE 1: NAME OF THE COMMUNITY AQUATIC ANIMAL CONSERVATION GROUPS (CAACGS) INVOLVED IN AQUATIC BIODIVERSITY MONITORING IN RIVER STRETCH OF MIDDLE RAPTI AND JHIMRUK WATERSHEDS

WATER SHED	CAACGS	NO. OF MONITORING EVENTS	RIVER/ STREAM	GPS POINT			NO. IN MONITORING TEAM
				LATITUDE	LONG-ITUDE	ELEVA-TION (MASL)	
Jhimruk Watershed	Airawati Dovan	2	Jhimruk River	27.931879°	82.942311°	386	12
	Amiliya Raha	2	Jhimruk River	28.079709	82.817395	744	15
	Bange Raha	2	Jhimruk River	27.981308°	82.983901°	559	23
	Bankala Raha	2	Jhimruk River	28.197319°	82.982965°	1077	16
	Damti Dovan	2	Jhimruk River	28.145902	82.905401	668	14
	Gudgude Raha	2	Jhimruk River	28.142216°	82.954137°	929	12
	Makre Raha	2	Lung Khola	28.179119°	82.884763°	950	14
	Naya Raha	2	Jhimruk River	27.965346	83.007811	535	14
	Rakasha Raha	2	Jhimruk River	27.996887°	82.954246°	595	15
	Tribeni Raha CAACG	2	Jhimruk River	28.025342	82.924133	641	17
	Joint Monitoring by the three CAACGs	2	Jhimruk and Lung Khola				30
	Paani/CS involvement	4	Jhimruk River, Hungadh Khola, Gartang Khola and Lung Khola				16
	Sub total	*26*					*198*
Middle Rapti Watershed	Baam CAACG	2	Praganna Irigation canal and dolai khola	27.838226°	82.647309°	269	29
	Baikha CAACG	2	Rapti River	27.823451°	82.636039°	267	23
	Kalmuda CAACG	1	Rapti River	27.833101°	82.752987°	296	12
	Mangra CAACG	1	Dolai Khola	27.843434°	82.617833°	261	6
	Raini CAACG	2	Rapti River	27.866751°	82.427784°	231	16

TABLE 1: NAME OF THE COMMUNITY AQUATIC ANIMAL CONSERVATION GROUPS (CAACGS) INVOLVED IN AQUATIC BIODIVERSITY MONITORING IN RIVER STRETCH OF MIDDLE RAPTI AND JHIMRUK WATERSHEDS

WATER SHED	CAACGS	NO. OF MONITORING EVENTS	RIVER/ STREAM	GPS POINT			NO. IN MONITORING TEAM
				LATITUDE	LONG-ITUDE	ELEVA-TION (MASL)	
	Rawa CAACG	2	Rapti River	27.837897°	82.521675°	246	30
	Rohu CAACG	1	Rapti River	27.833867°	82.591672°	258	20
	Sahar CAACG	1	Rapti River	27.818623°	82.660976°	270	13
	Sub total	*12*					*149*
	Total	**38**					**347**

5. ANALYSIS

5.1 FISH

Collectively 74 species of fish were recorded in the Jhimruk and Rapti rivers including their tributaries Arkha River, Gartang River, Dolai River and Sano Nadi (Annex II). Community-based biodiversity monitoring recorded a relatively lower number of fish species compared to the 76 species reported in the Rapti River Basin by the Paani Program (USAID Paani Program, 2020). The lowest diversity of fish was recorded in the three tributaries of the Jhimruk River, likely due to the cold temperature of those waters (Figure 8). The main stem of the Jhimruk and Rapti Rivers provide habitat for a significant number of fish species. CAACGs sampled and collected 41 species of fish from these rivers.

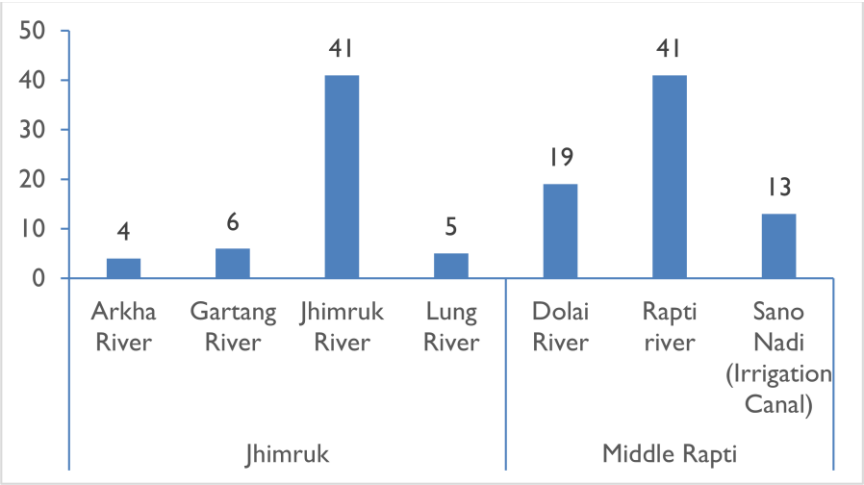

Figure 8: Number of fish species recorded by CAACGs during the aquatic biodiversity monitoring in different river and streams of Jhimruk and Middle Rapti Watersheds

As the main stem of the Jhimruk and Rapti River provides the ecological connection between upstream coldwater and downstream warmwater within the Rapti River Basin, the fish species assemblage in these rivers are related to seasonal migration of many fish species. As demonstrated in Table 2, the highest number of fish species (29) collected from Jhimruk river was during the

summer season, indicating that migratory species such as Mahseer (*Tor putitora*) and Goonch (*Bagarius* spp) contributed to species assemblage during their upstream migration towards the Jhimruk River. Similarly, species richness (39) increased in the Rapti River during winter coinciding with downstream migration of fish from the Jhimruk River.

TABLE 2: NUMBER OF FISH SPECIES OBSERVED BY CAACG IN DIFFERENT SEASON AND STREAMS OF MIDDLE RAPTI AND JHIMRUK WATERSHEDS

WATERSHED	RIVER/STREAM	SUMMER	WET	AUTUMN	WINTER
Jhimruk	Arkha River	NM	NM	5	NM
	Gartang River	7	NM	NM	NM
	Jhimruk River	29	19	11	NM
	Lung River	5	3	NM	NM
Middle Rapti	Rapti River	13	NM	NM	39
	Dolai River	NM	NM	NM	20
	Sano Nadi (Irrigation Canal	NM	NM	NM	13

NM-not monitored

Community-based monitoring (CBM) of aquatic biodiversity revealed the appearance of two new species of fish: Cheparo Machha and Jhojho Machha were identified in the main stem of the Jhimruk River during wet season sampling in July 2018 and summer sampling in March 2019 (Table 3, Figure 9). One species of turtle (Indian Roofed Turtle - *Pangshura tecta*) reappeared in Dolai River of Middle Rapti watershed which had not been observed due to overharvesting and habitat degradation. CBM also indicated that the long-range migratory fish species Mahseer (*Tor putitora*) has returned to streams and canals joining the Rapti River. Improved fish habitat as the result of declining destructive and illegal fishing, use of responsible fishing gear, and CAACG's river stretch patrolling efforts is thought to have influenced environmental changes that favor the appearance of new fish species and recurrence of absent species in these rivers.

TABLE 3: NEW APPEARANCE OF AQUATIC SPECIES OBSERVED BY CAACG IN DIFFERENT STREAMS OF MIDDLE RAPTI AND JHIMRUK WATERSHEDS

WATERSHED	RIVER/STREAM	NAME OF AQUATIC SPECIES	APPEARANCE STATUS	SEASON OF APPEARANCE	MONTH & YEAR OF FIRST APPEARANCE
Jhimruk	Jhimruk River	Chheparo Machha	New	Summer	July 2018
	Jhimruk River	Jhojho Machha	New	Summer	March 2019
Middle Rapti	Dolai River	Indian Roofed Turtle (*Pangshura tecta*)	Reappeared	Winter	February 2020
	Rapti River	Golden Mahseer, Sahar (*Tor putitora*)	Reappeared	Winter	January 2019

Chheparo Machha, Jhimruk River

Jhojho Machha, Jhimruk River

Indian Roofed Turtle, Rapti River

Golden Mahseer, Rapti River

Figure 9: Fish species new to Jhimruk River (above), and fish and turtle reappeared in Rapti River (below)

5.2 AQUATIC PLANTS AND INSECT

The survey provided the first list of aquatic plants recorded by the community (Annex III). A total of 36 aquatic and riparian plants were identified (21in Jhimruk Watershed and 20 in Middle Rapti Watershed) Aquatic plant diversity was low in the tributaries of Jhimruk and Rapti rivers (Figure 10).

CBM recorded 20 types of aquatic insects from the river and streams of the Jhimruk and Middle Rapti Watersheds (Annex IV). Aquatic insect diversity was highest in Rapti River (11), followed by Jhimruk River (8) and the recorded lowest diversity (1) was in the Arkha and Gortang rivers in Jhimruk Watershed (Figure 10).

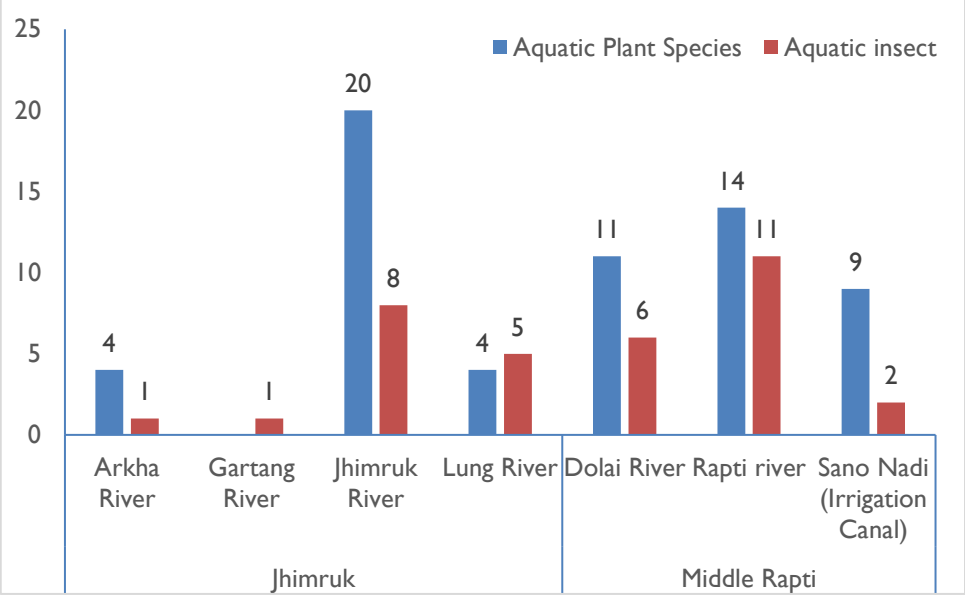

Figure 10: Number of aquatic plant and insects species recorded by CAACGs during the aquatic biodiversity monitoring in different river and streams of Jhimruk and Middle Rapti Watersheds

5.3 AQUATIC MOLLUSK AND CRUSTACEANS

This survey also inventoried mollusk and crustaceans in the Middle Rapti and Jhimruk watersheds (Annex V). A total of eight species of aquatic mollusk and two species of crustacean were recorded from the rivers of these watersheds (Figure 11). Mollusk diversity was high in Rapti River while Jhimruk River only had one species of mollusk. Six species of gastropods belonging to five families and two species of bivalve represented by a single family were found to inhabit in the Rapti River. The most common types of gastropod for consumption as flesh/meat were *Indoplanorbis exustus, Bellamya bengalensis* and *Thiara tuberculate.* Although the two species of bivalve were found in collection sites, the species *Lamellidens marginalis* (Lamarck) was most common for consumption. Mollusk are ecologically important because of their widespread distribution and biological filtration activity (Kasprzak, 1986) and also economically, used as food and production of freshwater pearls (Subba Rao and Dey, 1989). CBM's preliminary observations suggest that the habitat is healthy, and in a good condition of conservation. More extensive sampling is required in order to more accurately reflect species diversity at these sites.

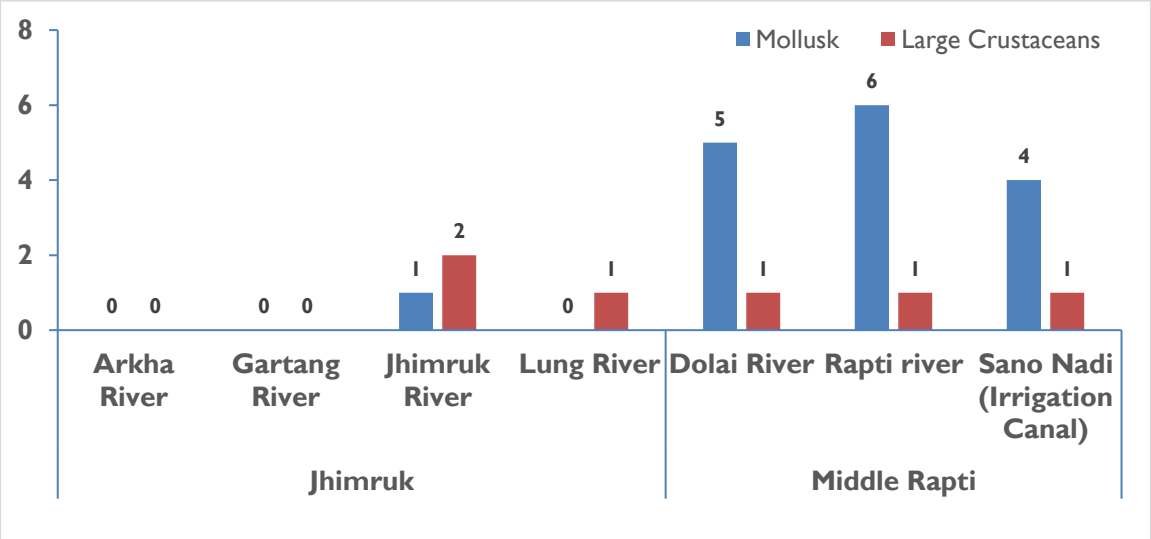

Figure 11: Number of mollusk and large crustacean species recorded by CAACGs during the aquatic biodiversity monitoring in different river and streams of Jhimruk and Middle Rapti Watersheds

Rohu CAACG recording the aquatic flora and fauna found in the river stretch of Rapti River, Middle Rapti Watershed

5.4 FRESHWATER CRABS, AMPHIBIANS AND REPTILES

Herpetofaunal inventory surveys were conducted at 21 sites of the Jhimruk and Rapti River. Two species each of freshwater carbs, amphibians and reptiles were observed in few sites of Jhimruk Watershed and in most of the sites in Middle Rapti Watershed (Annexes VI, VII, VIII). CBM did not observe these taxa in the Gartang River of Jhimruk Watershed or in the Sano Nadi of Middle Rapti Watershed (Figure 12).

5.5 WATER FOWL AND TERRESTRIAL BIRDS

Seven species of water fowl and 30 species of terrestrial birds were observed across the watersheds. Khole Haans (Water Duck) was the only water fowl that is dominant in Jhimruk river whereas six species of water fowl including Ruddy shelduck, Large Dabali, Small Dabali, Gaine, Talbhakta and Titihas were abundant in Rapti River. Similarly, the avifauna of the Rapti River features high diversity (22 species) compared to lower diversity (12) in Jhimruk River (Annex IX, X, Figure 12).

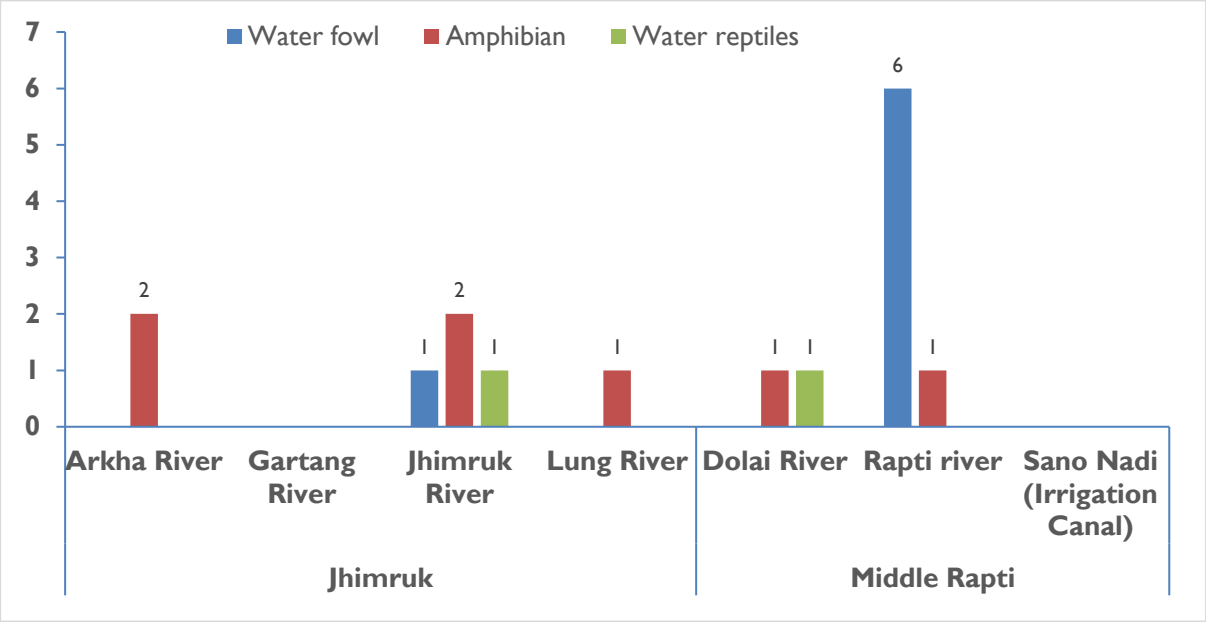

Figure 12: Species number of water fowl, amphibian and water reptiles recorded by CAACGs during the aquatic biodiversity monitoring in different river and streams of Jhimruk and Middle Rapti Watersheds

5.6 SPECIMEN MUSEUM

Fish Specimen Museum collectively managed by Baikha, Bam and Mangra CAACGs in Rapti RM, Middle Rapti Watershed

CAACGs in Rapti Rural Municipality, Middle Rapti Watershed established a small museum of specimen collected from the Rapti and Dolai rivers and Sano Nadi irrigation canal. The objective of the community-managed museum is to create an educational center using interactive exhibits that focuses on Rapti River's rich cultural history of fish and to raise local awareness of the need to change fishing practices to conserve and ensure the sustainability of Rapti River's aquatic biodiversity. The CAACG hopes to achieve this through inspiring educational exhibits, developing and maintaining scientific collections for display, and by fostering links with other museums and research centers

nationally. CAACGs noted that they need training to properly preserve the specimen and to know the type of information that should be recorded with each specimen.

5.7 COMMUNITY PERCEPTIONS OF AQUATIC BIODIVERSITY CONSERVATION

Local communities engaged in biodiversity monitoring believed that fish populations increased since Paani Program-supported conservation activities began in 2017. This was evidenced by the appearance of new species and the reoccurrence of previously absent fish species in the Rapti river. However, CAACG members noted that overfishing at the Bijuwar site of the Jhimruk River, water scarcity downstream at the Jhimruk hydropower plant, and illegal fishing by non-residents were major threats that negatively impacting fishery resources in the Jhimruk Watershed. Similarly, water pollution due to unregulated solid waste, excessive and haphazard riverbed gravel mining, illegal fishing by non-residents were major threats to aquatic biodiversity in Middle Rapti Watershed.

5.8 ASSESSMENT OF COMMUNITY-BASED AQUATIC BIODIVERSITY MONITORING

One of the methods to assess ecosystem health is through indicator taxa, for example the presence of large bodied fish in a river. They are species or higher taxonomic groups whose parameters, such as density, presence or absence, or infant survivorship, are used to determine the state of the ecosystem (Hilty and Merenlender, 2000). Indicator taxa provide (early) warning signs of environmental impacts, directly indicate the cause of change, provide continuous assessment over a wide range and intensity of stresses, are cost-effective to measure, and can be relatively easy to identify (Carignan and Villard, 2000). For example, metal pollution can be inferred from the abundances of mayflies (Clements et al., 2000). CAACGs have identified number of taxa including fish, aquatic plants, insects, amphibian and mollusks but they have limited capacity to analyze and interpret the outcome of community-based monitoring and correlate these findings with river health. Transforming knowledge of aquatic biodiversity into conservation planning requires CAACGs to build ties with the scientific community. Additional capacity building is necessary for CAACGs to independently direct ongoing monitoring and analyze the results and should closely cooperate with researchers.

The surveillance method used for community-based monitoring was at a medium-level of methodology rigor[1]. CAACG's generally did not record the volume of fish captured, catch per unit effort (CPUE) and number taxa by categories in the monitoring records. CAACGs record what they observed, but they do not know what to do with the recorded data.

Community-based monitoring schemes were carried out with the primary purpose of understanding large scale changes in aquatic biodiversity. They were also useful for awareness raising in local communities and for serving the long-term aims of biodiversity conservation, provided that there is strong legal recognition and support of the government and financial support of external agencies.

[1] The degree to which a monitoring method is perceived as generating relatively accurate and precise data.

The capability of CBM to generate reliable data is largely but not entirely dependent on the rigor of the protocol and level of training and supervision offered to local communities. Even where training and protocols are strong, successful implementation depends on the willingness and commitment of monitors. CBM may require temporary technical support from fisheries officers and external researchers before it can fully function on its own (Danielsen et al., 2008).

6. CONCLUSION AND RECOMMENDATIONS

Community-based monitoring and management of aquatic biodiversity is an approach to foster a simple and self-sustainable monitoring system to support the sustainable management of aquatic biodiversity. CAACGs have initiated aquatic biodiversity monitoring in their delineated river stretches and collected substantial data on the assemblage of aquatic biodiversity including fish, insects, plant, mollusk, reptiles, amphibian and waterfowl in the Rapti and Jhimruk rivers and their tributaries. The quality of data generated through community-based monitoring are subject to verification through collaboration with external expertise. Data collected by CAACGs is entered into the community biodiversity register, which helps create local ownership of the scheme and its results, and copies of the data can be shared with professional researchers for in-depth or larger-scale analysis. Systematic comparisons between professional and community-based monitoring approaches are needed, and there is a need to extend the focus of community-based monitoring from primarily aquatic biodiversity monitoring to consider social measures (e.g., governance in natural resource management). Meta-analytical tools (Gurevitch et al., 2001) may offer opportunities for combining the results of community-based monitoring to draw general conclusions and to track larger-scale trends.

The CAACG-based monitoring program constituted a fully internalized, local management system, and hence in principle provided the greatest local control over monitoring and decision making in natural resource management. However, monitoring programs undertaken without the involvement of external stakeholders may not improve collaboration between communities and, for example, government authorities or private sector (Seak et al., 2012). It can build local capacity and relations between local community and the authorities and can result in more rapid management interventions. Nevertheless, the approach needs further development and verification.

Improvement and continuation of the community-based monitoring systems could be accomplished through: (1) requiring that monitoring scheme produces regular reports on biodiversity trends; (2) sharing data among and between agencies and interested individuals; and (3) provision of appropriate backup support including sufficient training and capacity building on comprehensive monitoring methods for monitors and integration of local ecological knowledge into the community-based system.

The design of community-based monitoring should be based on existing norms and practices, integration of local ecological knowledge, and should take into consideration the need to coordinate with livelihood activities. There is also a need for coaching by professional experts in monitoring methods, analysis and interpretation of monitoring data so that regular reports can be produced. In order to ensure greater community participation in monitoring, management and conservation of aquatic biodiversity in rivers, the river stretch co-management approach and model should be strengthened and expanded across the Rapti River Basin.

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8. ANNEXES

ANNEX I. DATA TEMPLATE USED BY THE COMMUNITY GROUPS FOR RECORDING AQUATIC BIODIVERSITY OF RIVER STRETCHES, MIDDLE RAPTI AND JHIMRUK WATERSHED

Community Aquatic Biodiversity Registration Form

Date: _____

Local name of fish or aquatic organism: _____

English name fish or aquatic organism: _____

Scientific name fish or aquatic organism: _____

Name of river/stream/lake from where the aquatic organism is caught: _____

Location specific name of river/stream/lake: _____

Part of river from where the specimen caught

Litoral area: _____

Main stem: _____

Fishing implement used to caught the aquatic organism

Name of gear: _____

Number of species caught: _____

Identification of fish

Color: _____

Shape (head, abdomen, body morph): _____

Barbels (presence/absence, long/short and number) _____

Dorsal fin rays (No.) _____

Length of fish (cm) _____

Weight of Fish (g) _____

Trend of catch of this fish species Daily ☐ Occasional ☐

Is this species new to the location? Yes: ☐ No: ☐

Population estimation

Ratio of broods (bearer) in the caught population:

Trend of population increase or decrease of this species Increased ☐ Decreased ☐ Constant ☐

Reason of change in population: _____

Use value & uses of this species

Market value (NRs/kg): _____

Food value: ☐ Recreational value ☐ Medicinal value ☐ Cultural/religious value ☐

If the species has medicinal value, please explain: _____

Insert photograph of head region of the specimen	Insert photograph of whole body of the specimen

ANNEX II. LIST OF FISH SPECIES RECORDED BY LOCAL COMMUNITIES (CAACGS) DURING AQUATIC BIODIVERSITY MONITORING IN DIFFERENT RIVER STRETCHES OF MIDDLE RAPTI AND JHIMRUK WATERSHED, RAPTI RIVER BASIN (MAY 2017 TO SEPTEMBER 2020)

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
1.	Schizothorax richarsonii	Asala	+	+	+	+			
2.	*Botia almorhae*	Baghi			+			+	
3.	*Mastacembelus armatus*	Baam			+		+	+	
4.	*Macrognathus pancalus*	Bamswitee					+	+	+
5.	*Garra gotyla gotyla,*	Buduna Kalo, Buduna Pahelo			+		+		
6.	*Barilius bendelisis*	Chaali					+	+	
7.		Bulakiya					+		
8.		Bichhli Changi					+		
9.	*Channa gachua*	Charinga, Hile machha/pahelo, charinga		+	+	+			
10.	*Barilius bendelisis*	Chali Machha. Kara, Kara Tilauri			+				
11.		Chaurerwa Gherra					+		
12.	Balitora brucei	Chheparo			+				
13.		Chilti					+		
14.		Chipi/Pichi					+	+	+

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
15.	*Tor tor*	Chokre, Chokre, Mahseer, Sahar			+		+	+	
16.	*Barilius* sp.	Dharkaha Tilori	+	+		+	+		
17.	*Acanthocobitis botia*	Dhikrahawa Gherra					+		+
18.	*Xenentodon cancila*	Dhong					+		
19.	*Rabora daniconius*	Dira					+		+
20.	*Brachydanio rerio*	Dire					+	+	
21.	*Glossogobius giuris*	Duduwa						+	
22.	Schistura sp,	Gadera		+	+	+			
23.		Galhar					+		
24.		Ghotaila Karra					+		
25.	*Bengal danio*	Ghotaila Sidhra. Jilbulwa Sedhri			+		+		+
26.		Ghotaila Tillori					+		
27.		Ghorat			+				
28.		Grahan					+		
29.		Guguwari						+	+
30.		Gaincha		+	+				
31.		Gardi/Tite			+				
32.		Jhinga			+		+		+

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
33.	*Lepidocephalichthys guntea*	Jilbuluwa Gherra, Moti Gadeula, Gherti					+	+	+
34.		Jilbuluwa Sidhri					+		
35.		Jhojo			+				
36.	*Channa punctatus*	Kabra Changi, Kabra Charinga					+	+	+
37.		Kalo Jhinga					+	+	
38.	*Labeo calbasu*	Kaltauke			+				
39.	*Barilius* sp.	Kasahawa tillori			+		+		
40.		Katari					+		
41.		Kukur Jhinga					+	+	+
42.	*Labeo dero*	Kaltauke/Ghorat, Kalmuda, Tite			+		+		
43.	*Garra* sp.	Kalo Buduna			+	+			
44.	Tor putitora	Karanga, Choitar , Sahar, Mahseer			+		+		
45.	Neolissochilus hexagonolepis	Katle/Kande	+	+	+	+			
46.	*Puntius* sp.	Khaptaha Sidhra					+		+
47.		Khesksi					+		+
48.	*Crossocheilus latius latius*	Keki			+				
49.		Kwake			+				
50.		Manera			+				

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
51.	*Danio dangila*	Mardehni Sedhri						+	
52.	*Labeo* sp	Milki			+				
53.		Nakato			+				
54.	*Aspidoparia morar*	Paharu Tilauri					+		
55.	*Aspidoparia* sp.	Patharchepti					+		
56.		Patirka Tilori					+		
57.	*Barilius* sp.	Phaketa	+	+	+	+			
58.	*Barilius* vagra	Rani Phaketa			+				
59.	*Anguilla bengalensis*	Rajbaam/Raini			+		+		
60.	*Naziritor cheilynoides*	Ruti			+				
61.		Rato Pakho Machha	+						
62.	*Cirrhinus reba*	Sari Rawa						+	
63.		Sati Machha			+				
64.		Sephkhaini					+	+	
65.		Seto Jhinga						+	
66.		Sidhra			+			+	
67.		Sokma Sahar			+				
68.	*Bagarius bagarius*	Thed/Lato Thed, Goonch			+			+	

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
69.	*Mystus* sp.	Tengna					+	+	+
70.		Tilki					+		
71.		Undar/Unduwa			+				
72.		Uparteri Sedhri					+		
73.	*Crossocheilus* sp.	Yeki/Keki			+				
74.		Dunduwa Machha					+		
	Total		**5**	**7**	**36**	**7**	**41**	**20**	**13**

ANNEX III. LIST OF AQUATIC PLANTS RECORDED BY LOCAL COMMUNITIES (CAACGS) DURING AQUATIC BIODIVERSITY MONITORING IN DIFFERENT RIVER STRETCHES OF MIDDLE RAPTI AND JHIMRUK WATERSHED, RAPTI RIVER BASIN (MAY 2017 TO SEPTEMBER 2020)

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
1		Anbhaga					+		
2		Badaur						+	
3		Bhaisi Dubo			+				
4		Biriya					+	+	+
5		Budhe Jhar			+				
6		Chholni Ghass							+
7		Chari Amilo			+				
8		Dori Phurke Jhar			+				
9		Ekhpatiya						+	
10		Gude Jhar			+				
11		Ghode Dubo			+				
12	*Hydrilla* sp	Hydrilla/Patai			+		+	+	+
13		Hile Jhar			+				
14		Jaluka/Gabda			+		+	+	+
15		Jaluka/Gabda (Rato)			+				+

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
16		Jalkumbhi					+		
17		Jhauwa/Sitha				+	+		
18		Kans			+				
19		Kurkure jhar			+				
20		Kane Jhar			+				
21		Leu/Algae/Seuli	+		+	+			
22		Lalpatiya					+	+	+
23		Lerkut/Narkat					+		+
24		Lalphuluwa					+		
25		Muthi kada /Mathe Jhar			+				
26		Muthi Gond					+		
27	*Typha angustifolia*	Patero Jhar/Katar Gond, Narrowleaf cottail	+		+	+	+	+	
28		Paani Patiya						+	
29	Oxalis corniculata	Paani Amilo, Prickly chaff-flower					+	+	+
30		Pauri Ghass					+	+	+
31		Pauri Bhada						+	
32	*Rorripa nasturtium*	Sim Saag, Watercress			+				

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
33		Sauli/Sewar					+		
34		Topre Jhar			+				
35		Tite Jhar	+		+	+			
36		Una/Unyu/Kochiya	+		+				
	Total		**4**	**3**	**20**	**4**	**14**	**11**	**9**

ANNEX IV. LIST OF AQUATIC INSECTS RECORDED BY LOCAL COMMUNITIES (CAACGS) DURING AQUATIC BIODIVERSITY MONITORING IN DIFFERENT RIVER STRETCHES OF MIDDLE RAPTI AND JHIMRUK WATERSHED, RAPTI RIVER BASIN (MAY 2017 TO SEPTEMBER 2020)

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
1		Barha					+		
2		Batuke Kira					+		
3		Bot/Chepto Bot/Bote Kira				+	+	+	+
4		Butterfly			+				
5		Bobali Kira			+				
6		Chapar Gokta			+		+	+	

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
7		Chepto Kira					+		
8		Dragonfly Larvae	+		+		+	+	+
9		Dibunni		+	+	+	+	+	+
10		Dhobi Kira	+		+				
11		Dhunge Kira					+		
12		Ghumni Kira						+	
13		Ghopte Kira					+		
14		Gokta				+	+	+	
15		Jalari			+				
16		Jhate Kira			+	+			
17		Jhate Kira/Khetari			+	+			
18		Jhinge Kira					+		
19		Lamo Bot						+	
20		Syani Kira					+		
	Total		**2**	**1**	**9**	**5**	**12**	**7**	**3**

ANNEX V. LIST OF AQUATIC MOLLUSK RECORDED BY LOCAL COMMUNITIES (CAACGS) DURING AQUATIC BIODIVERSITY MONITORING IN DIFFERENT RIVER STRETCHES OF MIDDLE RAPTI AND JHIMRUK WATERSHED, RAPTI RIVER BASIN (MAY 2017 TO SEPTEMBER 2020)

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
1	*Bellamya bengalensis*	Chepto Ghonghi					+		
2	*Lymnaea luteola f.typica*	Ghonghi					+	+	
3	*Indoplanorbis exustus*	Golo Ghonghi					+	+	+
4	*Parreysia favidens* (Benson)	Kubri Sutahi					+	+	+
5	*Thiara tuberculata*	Lamo Ghonghi					+	+	+
6	*Lamellidens marginalis*	Sipi Kira							
7	*Lymnaea luteola f.ovulis*	Sankhe Kira			+				
8		Sutahi					+	+	+
	Total		**-**	**-**	**1**	**-**	**6**	**5**	**4**

ANNEX VI. LIST OF FRESHWATER CRABS RECORDED BY LOCAL COMMUNITIES (CAACGS) DURING AQUATIC BIODIVERSITY MONITORING IN DIFFERENT RIVER STRETCHES OF MIDDLE RAPTI AND JHIMRUK WATERSHED, RAPTI RIVER BASIN (MAY 2017 TO SEPTEMBER 2020)

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED			MIDDLE RAPTI WATERSHED			
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
1		Dudhe Gangata			+				
2		Gangata			+	+	+	+	+
	Total		-	-	2	1	1	1	1

ANNEX VII. LIST OF AMPHIBIANS RECORDED BY LOCAL COMMUNITIES (CAACGS) DURING AQUATIC BIODIVERSITY MONITORING IN DIFFERENT RIVER STRETCHES OF MIDDLE RAPTI AND JHIMRUK WATERSHED, RAPTI RIVER BASIN (MAY 2017 TO SEPTEMBER 2020)

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED			MIDDLE RAPTI WATERSHED			
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
1		Bhyaguta	+		+	+	+	+	
2		Paa/Gills/Chepa	+		+				
	Total		2	-	2	1	1	1	-

ANNEX VIII. LIST OF WATER REPTILES RECORDED BY LOCAL COMMUNITIES (CAACGS) DURING AQUATIC BIODIVERSITY MONITORING IN DIFFERENT RIVER STRETCHES OF MIDDLE RAPTI AND JHIMRUK WATERSHED, RAPTI RIVER BASIN (MAY 2017 TO SEPTEMBER 2020)

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
1		Kachhuwa						+	
2		Snake (water snake)			+				
	Total		=	=	1	=	-	1	=

ANNEX IX. LIST OF WATER FOWLS RECORDED BY LOCAL COMMUNITIES (CAACGS) DURING AQUATIC BIODIVERSITY MONITORING IN DIFFERENT RIVER STRETCHES OF MIDDLE RAPTI AND JHIMRUK WATERSHED, RAPTI RIVER BASIN (MAY 2017 TO SEPTEMBER 2020)

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
1	*Tadorna ferruginea*	Chakhewa, Ruddy shelduck					+		
2		Dabali					+		
3		Dabali (Sano Kalo)					+		
4		Gaine/Gain					+		
5		Khole Hans			+				

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
6		Talbakta					+		
7		Titihaas			+	-	+		
	Total		-	-	2	-	6	-	-

ANNEX X. LIST OF BIRDS RECORDED BY LOCAL COMMUNITIES (CAACGS) DURING AQUATIC BIODIVERSITY MONITORING IN DIFFERENT RIVER STRETCHES OF MIDDLE RAPTI AND JHIMRUK WATERSHED, RAPTI RIVER BASIN (MAY 2017 TO SEPTEMBER 2020)

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
1		Baaj					+		
2		Bhuijhyatti					+	+	
3		Dubchholuwa						+	
4		Dhakchuira						+	
5		Dhobi Chara			+	+	+	+	
6		Gothe Chara			+				
7		Gauriya Bakula (Heron)			+			+	
8		Gauthali					+		

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
9		Phaketi chara			+				
10		Jhyam Jhutti					+	+	+
11		Jaluka chara			+				
12		Kaag					+		
13		Khakhaura/King Fisher					+	+	
14		Khakhaura Sano/King Fisher							+
15		Khairi Bakula							+
16		Kalyang Kulung chara/Ghanphor			+				
17		Kurkure Hans			+				
18		Lalchar/Lalsar					+		
19		Pahare Chara	+		+				
20		Paltai					+	+	
21		Pathar chyatti					+		
22		Pakhiyari					+	+	
23		Pani Khareto chara			+				
24		Phechungha						+	
25		Rato Bakula						+	
26		Seto bakula					+	+	+

S.NO.	SCIENTIFIC NAME	LOCAL NAME	JHIMRUK WATERSHED				MIDDLE RAPTI WATERSHED		
			ARKHA RIVER	GARTANG RIVER	JHIMRUK RIVER	LUNG KHOLA	RAPTI RIVER	DOLAI RIVER	SANO NADI (IRRIGATION CANAL)
27		Phiste chara			+	+	+		
28		Seto bakula					+	+	
29		Tare chara			+				
30		Tihula					+	+	
	Total		**1**	**-**	**11**	**2**	**15**	**14**	**4**