ESSENCE - International Journal for Environmental Rehabilitation and Conservation
Volume VIII: No. 1 2017 [214 – 223] [ISSN 0975 - 6272]
[www.essence-journal.com]

Biodiversity and Ecosystem Services of Ramganga Reservoir (Uttarakhand)

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Received: January 29, 2017 | **Accepted**: February 20, 2017 | **Online**: June 30, 2017

Introduction

"O sage Naarad! Among the places on earth, the land of India is blessed, In India- the land of Himalaya is blessed and the region in Himalayas where Ganga is born is especially blessed because this is the place where she exists in confluence with God." ***(Skandapuran-Kedarkhandam, Chapter 149, Shloka 39-40)***

Pauri Garhwal is a district in Uttarakhand state of India. Its headquarters is at Pauri. Pauri Garhwal district is ringed by Haridwar, Dehradun, Tehri Garhwal, Rudraprayag, Chamoli, Almora and Nainital districts from three sides. The southern boundary of Pauri Garhwal district touches with the Bijnor district of Uttar Pradesh. This district falls partly in the Gangetic plains and a major part in the Himalayan North.

Uttarakhand is gifted with abundant natural resources – scenic vistas, forests, rivers, wilderness, wildlife among many others. Over nine hundred glaciers feed its major rivers and many of their tributaries. Rain and spring-fed rivers nourish the mid-Himalayan region of the state, where most of the mountain population dwells. Uttarakhand is India's newest himalyan state. Here altitude is the principal determining factor for natural processes and human activities. Rapid changes in altitude across short distances, leading to tremendous variation in climate, have generated a profusion of geological, geographical, biological and cultural diversities in the state.

Uttarakhand is characterized by a tremendous variation in climate across the transverse zones. It varies from the sub-tropical humid climate of the *terai* region to the tundra-like climate of the Great Himalaya ridges. The climatic variation is even more dramatic along the slopes of the mountain ranges. Forests are the backbone of Uttarakhand's environment. They account for about 65 per cent of the state's geographical area. They are storehouses of biodiversity. Scores of plants in the forests are wild relatives of cultivated crops and represent an invaluable genetic resource. Many wild plants have medicinal properties. The state's forests also

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have an abundance of wild animals. The snow leopard, musk deer, Himalayan brown bear, Asiatic black bear, and pheasants like Western Tragopan, Himalayan Monal and cheer pheasant found in the Great Himalaya region are endangered species. Elephants and tigers abound in the Shivaliks and the *terai* regions.

Ramganga river originates from the shivalik range in the outer Himalayas of district Chamoli and after flowing 125 kms. Through hilly terrain it emerges into plain at Kalagarh dam site. Ramganga river is a tributary of River Ganga. In order to harness, the potentialities of Ramganga River, the Uttar Pradesh state Government decided to construct a Dam across it at a site Which is 3km. Upstream from the place where river enters the plains. The valley is known by the name of Patli Dun. The sub-himalayan region where the dam is situated is known by the name of Shiwalik Ranges.

Ramganga dam is situated about 3 km upstream of Kalagarh villages in district Pauri Garhwal of Uttarakhand. It is about 110 km to the North-East of Moradabad. The exact location of the Dam site is latitude 29º 31' 13" North and longitude 78º 45' 35'' East. It is the first venture in the Himalaya and has laid the foundation for still greater venture in these mountains. Government authorized its construction in 1961.

Hydrological Characteristics

Ramganga dam has created a lake of 80 sq. kms area with a storing capacity of 2448 million cum of water which provides irrigation facilities to the 6.01 lac hect. land and additional production of food grain to the tune of 3 lacs tones. For storing and regulating water, the dam and reservoir projects construction can change the process of runoff and sediment downstream, and so on, which might impact downstream agriculture and causes channel erosion. According to WCD (2000), 46 per cent of the water in the 108 most important rivers of the world is first flowing into a reservoir before it continues its way to a natural lake and/or to the sea. The efficiency of reservoirs at trapping sediment is frequently reported as 70 -90 per cent of the environmental hazards of dams and reservoirs. Modification of hydrological regime as formation of reservoir (hydroflushing, sometimes with important variations in water level flood, low water level, runoff distribution in general), change of groundwater levels and accumulated high concentrations of suspended material during flushing events. Detrital (terrigenous) sedimentation trapping of suspended matter and bed load decreased the down-river sediment transport with accumulation and retention of organic matter. Change of temperature profile (and temperature Change of down-river water temperature and linked physical parameters) contributed the function of viscosity meteorology and seasonality impact on biochemical cycles, e.g. oxygen depletion. Modification of physico-chemical water parameters due to increase of reservoir water salinity in downstream river and groundwater. The contribution to organic production (phytoplankton and plant growth) and nitrogen cycling (mostly nitrification) among water quality, organisms (e.g. macrophytes) and sediment contents of reservoir responsible for. N-loss to atmosphere

(NO_2, N_2), Oxygen depletion by nitrification Other nutrients cycles of iron, manganese, sulphur, silica delivered from the watershed have to changing water composition sediment volume from upstream to downstream of reservoir (Sundborg, 1992; Toniolo and Schultz, 2005).

The hydrological parameters, temperature is the most critical environment factor influencing metabolism, growth, reproduction, distribution, survival of flora and fauna in fresh water reservoir (Singh and Mathur, 2005). Temperature also affects mainly productivity, solubility of oxygen and other gases in reservoir ecosystem. The typical water temperature in reservoir effects vertical thermal stratification. The constructed dam and reservoir on the river greatly change the hydrological processes and hydraulic conditions of the river and also modify the thermodynamic state of the river which thus changes water temperature. Dam and reservoir project mainly focuses on water temperature, aquatic livings, terrestrial livings, hydrological regime and the resettlement of migrants from reservoir. The hydrological characteristics of Ramganga reservoir is represented in Table 1.

Biodiversity of Ramganga reservoir

Biodiversity is the most important ingredient as a biological resources of an ecosystem. Ecological consequences of damming that have been mentioned in the literature are loss of forests and wildlife habitats, loss of species populations and the degradation of upstream catchment areas due to inundation, loss of aquatic biodiversity, including upstream and downstream fisheries, and loss of the services of downstream floodplains. The impact of dams and reservoir projects on aquatic livings focused on fishes, reptiles, birds and mammals. The dam blocking has a serious impact on migratory fishes due to destroying and distributing their spawning, breeding and their habitats, which forces the fishes from the river water gradually transform into the lakes fishes and make some environmental- sensitively fish species be endangered. Ecological theory suggests high biodiversity is associated with greater efficiency of resource use within ecosystems (Gamfeldt and Hillebrand, 2008). Biodiversity might also determine the resilience or maintenance of ecosystem services (Haines-Young and Potschin 2010), as systems with high biodiversity can better adapt to future conditions or are potentially more resistant to biological invasions (Taylor and Duggan 2012). Crocodile have of varieties of reptiles have growth in the pocket of lake. Reservoir has provided added attraction of birds. Therefore, the number and types of fishes will change, which impact remarkable local fishes. The most common local and migratory birds also observed around the periphery of Ramganga reservoir as Bulbul, Golden backed wood peacker, Blue fly catcher, Wintering water fowl, Brahminy, Green shank, Eagles, Woodpecker, Red headed laughing thrush. The Ramganga reservoir provide a natural water resource to most of the wild mammals represented as Tiger, Panther, Leopard cat, Musk deer, Gaural, Beer, Bat, Rhesus Monkey and Squirrel. Jordi and Ming (2009) was studied on biodiversity of three Gorges reservoir from Yangtze River of

Central China. The result revealed that there were 6000 plant species, over 500 terrestrial vertebrates and about 160 species of fish were found.

In Ramganga reservoir have been occurred about 40 fish species and conserves a wide occurrence of icthyofaunal diversity. These fish species are identified belonging to 5 Balitoridae, 1 Belonidae, 2 Channidae, 4 Cobitidae, 23 Cyprinidae, 1 Mastacombellidae, 4 Sisoridae (Table-2). The different fish species found in reservoir are *Labeo rohita, Catla-catla, Cirrhinus mrigala, Labeo calbasu, Labeo gonius, Labeo bata, Cyprinus carpio, Ctenopharangodon idella, Sperata seenghala, Mystus cavassius, Mystus tengara, Wallago-attu, Ompok pabo, Ompok bimaculatus, Clarius batrachus, Channa marulius, Channa gaucha, Channa puntatus, Mastacembelus armatus, Xenentoden cancila, Heteropneustes fossilis, Gadusia chapra, Notoptarus chitala, Notoptarus- notoptraus, Hypophthalmichthys molitrix.* The distribution and composition of the fish species in each habitat were closely associated with various factors such as the availability of food, breeding sites, water current, depth, topography and physico-chemical properties of water (Harris, 1995). The aquatic macrophytes also contributed in the ecological dynamics of Ramganga reservoir. Ten species of fresh water aquatic weed such as *Marsilea quadrifolia, Ipomea aquatic, Hydrilla verticillata, Chara species, Salvenia natans, Pistia stratiotes, Colocasia esculata, Scripus erectus, Nymphae stellata* and *Nelumbo nucifera.*

Ecosystem/Ecological Services

The concept of ecosystem services provides a robust rationale for biodiversity conservation complementary to traditional arguments based on intrinsic value. It also provides a mechanism for optimizing investments in biodiversity conservation and directing them to where they are most useful (Kinzing *et al*., 2007).

Ecosystem services are the processes and conditions of natural ecosystem that support human activity and sustain human life (Daily, 1997). The type, quality, quantity of services provide by an ecosystem are affected by resources use decisions of individuals and communities (Jack *et al*., 2008). At the landscape level, conservation of biodiversity and maintaining the sustained flow of ecosystem services that it provides are now increasingly becoming the focus of ecosystem based natural resource management (Ehrlich and Wilson 1991; Fisher *et al*., 2008). Some recent studies have attributed the sustained flow of services to the health of ecosystem resulting from improved conservation (Naidoo and Ricketts 2006; Chan *et al*., 2006). Despite the vital importance of ecosystem services, there has not been much progress in incorporating these into conservation planning, largely, due to poor characterization of the flow of services from conserved ecosystem such as Pas (Chan *et al*., 2006) as well as for advancing human well-being. Valuation of ecosystem services can help resources managers deal with the effects of market failures, by putting a price on use and nonuse values, which otherwise are generally

hidden from traditional economic accounting (Daily *et al*., 1997).

Assessment of Ecological Services

The ecosystem services are viable means of evaluating the full range of values provided by reservoir. There are many socio-ecological benefits of Kalagarh dam like Power generation, Emission reduction, Crop Irrigation, Drinking Water, Flood Control, Aquaculture, and tourism activities *etc*.

Hydropower generation: Hydrological modifications associated with dams can have negative effects on ecology and ecosystem services by, for example, preventing fish passage along river systems and reducing habitat for wading birds that would otherwise nest on river flats (e.g. the critically endangered black stilt, *Himantopus novaezelandiae*). The diverse ecotonal gradients of shores and littoral zones are often negatively impacted by the rapid and/or large water level variations common in hydroelectric reservoirs. For example, the frequency of immersion and the duration of exposure to more extreme water levels have been shown to be major factors affecting submerged aquatic macrophyte communities in lakes (Riis and Hawes 2002). A power generation station with peaking capacity of 198 M.W. has been constructed which generates about 454×10^6 K.W. units annually to augment the power supply of the state. The Ramganga project will also yield 451 million units of power annually. However, the installed capacity of power house provides the sufficient electricity to about 4500 villages of catchment basin of reservoir.

Water quality and Drinking water supply: Dam construction can expand the water area of the reservoir, deepen water depth, slow water flow rate and decrease the diffusion of pollutants and thus the concentrations and distribution of pollutants in the waters of the reservoir will be changed. Reservoir stores a lot of nutrients such as nitrogen, phosphorous, potassium and thus promoting algae growth. This might cause the potential eutrophication of the reservoir. Additionally, irrigation development will also adversely affect water quality No drinking water is supplied directly from the Dam to any village or township. Indirectly 5.66 cumecs drinking water is supplied to Delhi. In the rural areas the network of channels have raised for drinking and other purposes. An additional 5.75 lac hactares of land has been provided with irrigation facilities yielding an extra 3.00 lac tons of food grains.

Flood: Reservoir are the large number of artificially constructed fresh water impoundments where water is retained to serve the needs of man. Reservoir is the important sources of water in all over the world. Some of reservoir is constructed as flood control detention storage to buffer the different flow during dry and wet season, although most of them, currently have multipurpose function. The Ramganga River which used to create havoc during flood has been tamed and its basin after detailing water in the reservoir is being used for agriculture by cultivators of the downstream area. About 454 million units of hydro power is being generated per year from the Ramganga power house.

The Ramganga river project is the multi-purpose project such as bring in additional benefits of flood control and power generation. It was imperative to store flood water in artificial reservoir to facilitate irrigation as well as power generation by constructing dams at suitable sites. This project is one of the few storage schemes proposed in Uttar-Pradesh. It has provided irrigation to new areas on all the canal system and increased the firm power available in the combined Ganga-Sarda-Yamuna Ramganga grid to a large extent. The reservoir with a flood storage of 24,500 million cumecs from 313,400 hactares of catchment area provides a high degree of flood control. The project also provides protection against floods in the flood plain of Ramganga River in Sahajahanpur, Hardoi, Moradabad, Rampur, Barreilly and Farrukhabad district where it joints Ganga River. It would also provide substantial flood protection to the districts of Moradabad, Rampur, Bareilly, Shahjahanpur, Bijnor and Farrukhabad**.**

Dams provide significant benefits for flood control and protection of human infrastructure; they can also impact downstream species and habitats. Most dam's moderate peaks and troughs of river discharge. This may be an unfavourable attribute of dams because floods can have a cleansing and renewing effect by scouring excessive growths of periphyton, organic matter, and fine sediment that may otherwise degrade aquatic habitat and ecosystem services (Quinn and Raaphurst 2009). When dams are filling, extended periods of low flows can result in proliferations of periphyton, including the toxin-producing cyanobacterium *Phormidium* sp. Dry mats of *Phormidium*, exposed at low flows, have caused the deaths of dogs that have consumed them (Heath *et al.,* 2011).

Migrants: Dam and reservoir development will have an important influence on resettlement from the reservoir area, which is the direct influence on regional society and economy. The migration of pollution is caused by project land and reservoir flooding. And the damage or arable lands, houses, infrastructure will directly impact the migrant's production and living. After construction of Ramganga reservoir, the catchment basin has been developed as rapid growth of agriculture and cottage industries benefitting all sectors of peoples from different parts of country.

Aquaculture: Reservoir contribute up to a significant mark to the inland fisheries of India which has been approximately 93,000 tonnes (Anon., 2006). More than 800 numbers of reservoirs scattered over various river system not only facilitate irrigation but also are used for fish resource Reservoir conserve a variety of native riverine fish species as well as introduced species which leads and supports commercial fisheries. A large number of varieties of fishes have grown up. More than 40 families of fisherman are engaged in capture fishery in Ramganga reservoir and earned a good income for livelihood to their family. Due to its economic potential, many reservoirs pond have become popular tourism and water based recreational sites or commercial fishing activites.With the creation of vast lake spread over an area of 80 sq.kms, has enhanced the

aquatic life. A large number of varieties of fishes have grown up. Temperature takes important physiological phenomenon of fishes such as feeding, respiration, osmoregulation, growth and reproduction under control (Avsar, 2005). The observed fish species are given in table 4. The improvement of reservoirs is a recent development in fishery management and is still in its infancy. It has provided added attraction of birds.

Miscellaneous socio-economic benefits

Large dam projects may cumulative effects on the natural environment at various scales and of different orders. The fringes of such large extensive reservoirs have promoted forest growth around the lakes in a much larger area than area submerged and of better class. Increased availability of water has resulted increases in humidity promoting more greenery. Services provided by reservoir in terms of recreation are numerous and include a range of activities such as boating, fishing, swimming, hiking, kayaking, and water fowl hunting. The network of metallic roads provided good transport facilities to local peoples to assess the better oppurtunities as health, education, marketing and employments. Soil conservation measures and afforestation taken up in Ramganga catchment has gradually checked the soil erosion, reducing the rate of siltation of reservoir approaching the equilibrium condition. Most of the staff employed was from nearby project area and this resulted in vast employment generation. The overall effect of this projects area in particular and overall improvement of the economy of the state in general. Kalagarh dam have some drawbacks like Habitat alteration, Fisheries declines, Population displacement, Sediment capture, Disruption of flooding, Risk of failure recreational opportunities.

Features	**Area**
Longitude	78º-45'-35''
Latitude	29º-31'-13''
Catchment Area above the Dam site	313400 hectare
Mean annual rainfall in the Catchment	1552 m.m
Reservoir elevation	366.86 m
Reservoir area	7831 Hectare
Length at River bed	91.40 m
Base width at deepest point	337.00 m
Discharge at EL. Tunnel	1,14,500 Cusec
Velocity at EL.Tunnel	46.22 m/sec
Submerged area at EL. 365.30	7831 Heactare
Water required on full load for power generation	2760 Cusec/unit

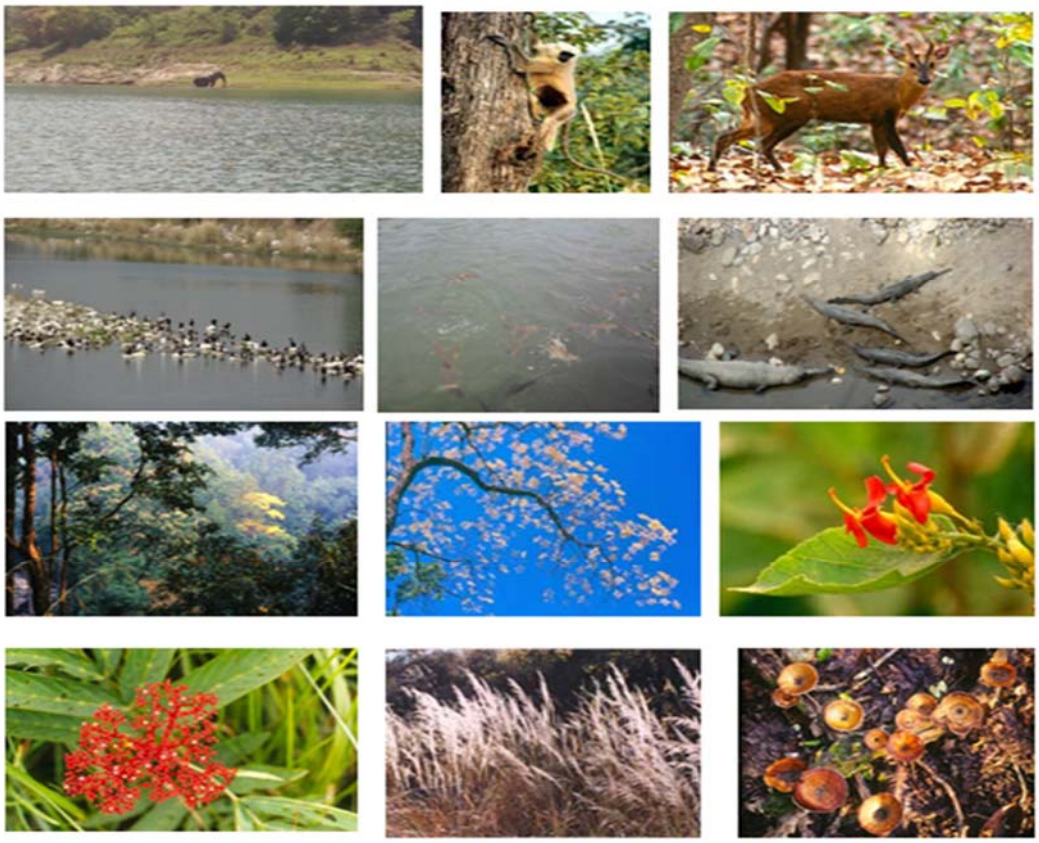
Table 1: Current hydrological characteristics of Ramganga reservoir

S. No.	Family	Fish Species
1	Balitoridae	*Nemachelius bevani ,N.botia, N.gharwali, N.montanus, N.rupecola*
2	Belonidae	*Xenentodon cancila*
3	Channidae	*Channa gachua, C.puntatus*
4	Cobitidae	*Botia almorhae, B.lohachata, B.rostrata, Lepidocephalus guntea*
5	Cyprinidae	*Barilius barila, B.bamba, B.bendelisis, B,sharca, B.vagra, Catla catla, Chanagunius changunio, Crossochaelius changunio, Crossocheilus latius latius, L.rohita, L.dero, Oxygaster bacaila, Puntius.conchonius, P.sophore, P.ticto, , P.vittatus, Raiamas bola, Schizothorax plagiostomus, S.progatue, S.richardsonii, Tor.putitora, T.tor*
6	Mastacembellidae	*Mastacembelus armatus*
7	Sisoridae	*Bagarius bagarius, Glyptothorax pectinoptrus, Luguvia sp., Pseudaecheneis sulcatus*

Table 2: Current status of fish diversity in Ramganga reservoir

S. No.	Botanical Name	Common Name	Application
1	Acacia Arabic	Babul	Gum Arabic
2	Egle maemelos	Bel	Atonic diarrhea and dysentery
3	Artemisia vulgris	Pati	Fever
4	Boenning verigata albiflora	Pisu-ghas	Medicine for poultry
5	Bauhinia verigata	Kachnar	Skin diseases, Dysentry,Ulcer
6	Bombax malabarium	Semal	Tonic
7	Cinnamomum tamala tej	Tejpat	Used as spice
8	Aconitum hetrophyllum atis	Indian Atees	Tonic, febrigue, aphrodisiac

Table 3: Medicinal plants near the periphery of Ramganga reservoir



Pic.1:Flora and Faunal diversty around the Ramganga resrevoir

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