# BIODIVERSITY AND ECOSYSTEM ANALYSIS WITH REFERENCE TO TRADITIONAL WATER HARVESTING SYSTEMS

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## Introduction

Water is essential to all living organisms, and in turn the biosphere plays a crucial role in the transportation, transformation and redistribution of water on local and regional scales. Biodiversity, the total variability of life on Earth, at the scale of functional groups or species also plays an important role in determining the distribution and rate of movement of water. Vegetation plays the primary role in transferring water from the soil to the atmosphere; plants and animals also have significant effects on the movement of water into the soil. In terrestrial systems, living organisms often regulate the magnitude and rate of flow of water from one site to another. Unfortunately there are few experimental studies exploring the links between biodiversity and water.

## Human-induced stress on biodiversity

Human-induced perturbations affect biodiversity both directly and indirectly through changes in land and water use. (fig.1). Changes in land and water use directly affect biodiversity and simultaneously modify the composition of the atmosphere and the climate. The alterations of land and water use include the overexploitation of resources such as in overfishing and overgrazing as well as drastic transformations such as the conversion of forest into croplands.

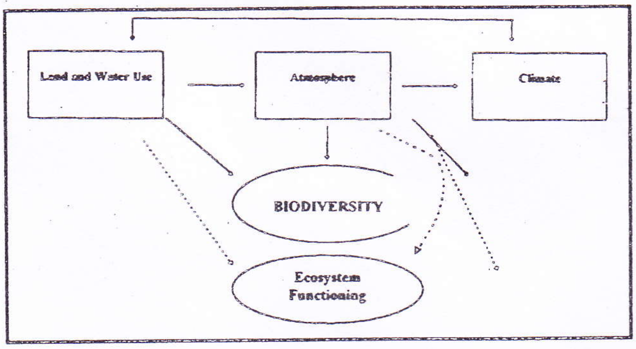


Fig.1 : Conceptual model of the effects of human-induced perturbations on bio-diversity and ecosystem functioning. (After UNEP, 1995)

Changes in climate and in the composition of the atmosphere also directly alter biodiversity. Changes in biodiversity in turn modify the functioning of the populations, ecosystems and landscapes. Finally, these changes feed back into land-use patterns, atmosphere composition and climate, accelerating and decelerating the rate of global change and the impacts of human activities.

## Climate and land use pattern in Raipur

Raipur, capital of Chhattisgarh state is a major urban centre. The city is administered by the Raipur Municipal Corporation. The area has tropical climate with wide temperature fluctuation. The mean maximum temperature during summer is 43°C and that in winter is 28°C, the mean minimum temperature in summer and winter is 29°C and 12°C, respectively. The railfall in the region is due to southwest monsoon between the middle of June to middle of October. The average number of rainy days is 60 and average annual rainfall is 1290 mm. The mean relative humidity in July-August is 89% (maximum) and is 40% in April-May (minimum).

The area allotted per land use category in Raipur for development till 1991, as per the Town and Country Planning Department is as follows, residential 23 Sqkm. (13.23%), commercial 2.8 Sqkm. (1.61%), industrial (4.89%), public utility 9.5 Sqkm (5.46%), recreational 5.5 Sqkm. (3.16%) and for transportation 8.2 Sqkm. (4.71%).

## Soil distribution and geology of Raipur

Soil distribution and geology plays a vital role in occurrence and distribution of surface and groundwater. Geologically, the area is occupied by Chandi Formation of Raipur Group, which belongs to Chhattisgarh Supergroup. These comprise horizontal to gently dipping Newari stromatolitic limestone and Deodonger shale and sandstone. Newari Member consists of purple to gray stromatolitic limestone intercalated with calcareous shale. The limestone is generally massive to thick bedded and karstic in nature. Deodonger Member overlies the limestone, with a sharp contact. Deodonger Member consists of khaki shale characterised by alternate shale-sandstone layer and massive ferruginous sandstone facies.

The primary source of groundwater recharge in and around Raipur is due to precipitation. The city receives on an average 1200mm of annual rainfall during the months from June to September. River Kharun is the perennial source of water, which flows nearby Raipur other being Chokra nala and Kolhan nala, which runs dry during the month of January or thereafter. All the surface water bodies in Raipur were demarcated on the drainage map. The abandoned limestone quarries also store the surface runoff water and serves for considerable time of the year.

During the ground truth survey for the census of ponds and lakes as demarcated on the toposheet, it was observed that some ponds have been reclaimed and few others are in the state of progress. The flooding and disposal of surface water runoff is a major problem during monsoon due to lack of storm water routing and domestic sewage system. The details of existing large ponds are given in Table 25.

Table No. 25

**WATER BODIES IN AND AROUND RAIPUR CITY**

**A. Kankali Talab**

| | |
|---|---|
| Name of the water body | Kankali Talab |
| Locality | Kankali Para |
| Period of construction | 1660 |
| Constructed by | Late Mahant Kripal Giri |
| Purpose of construction | Religious, near Kankali Temple |
| Owner of water body | Private |
| Source of water body | Rain water, groundwater seepage |
| Water spread area | 0.770 Hectares |
| Water holding capacity | 0.50 lakh $M^3$ |
| Catchment area | Surface runoff from residential areas, but surrounding area is compounded |
| Land use of catchment | Residential area |
| Authority maintaining the water body | Private |
| Current use of water body | Bathing, idol immersion (religious) |
| Current status | Polluted water |
| Associated problem of water body | Stagnant polluted water silting |
| Remedial measures | Desilting, water quality improvement, ghat construction, lighting |

**B. Telibandha Talab**

| | |
|---|---|
| Name of the water body | TelibandhaTalab |
| Locality | Telibandha (adjacent to Jalvihar Colony) |
| Period of construction | 1935 |
| Constructed by | Dinanath |
| Purpose of construction | General use |
| Owner of water body | Raipur Municipal Corporation |
| Source of water body | Rain water, Drain water |
| Water spread area | 12.550 hectares |
| Water holding capacity | 2.75 lakh $M^3$ |
| Catchment area | |
| Land use of catchment | Residential area |
| Authority maintaining the water body | Raipur Municipal Corporation |
| Current use of water body | General use and for religious purposes |
| Current status | Unhealthy, polluted |
| Associated problem of water body | Water pollution, silting, encroachement |
| Remedial measures | Land use control over catchment, water quality improvement lighting |

**C. Kho Kho Talab Group** (Kho Kho Talab, Bandhwa Talab, Pahladwa Talab)

| | | |
|---|---|---|
| Name of the water body | Kho Kho Talab, Bandhwa Talab, Pahladwa Talab | |
| Locality | Between Lakhe Nagar, Purani Basti and Khushalpur | |
| Period of construction | 1830 | |
| Constructed by | Kodand Singh | |
| Purpose of construction | General use and religious | |
| Owner of water body | Pahlada - Raipur Municipal Corporation, Other - Private | |
| Source of water body | Rain water, Drain water | |
| Water spread area | Kho Kho 5.060 Hec. | |
| | Pahladwa 2.840 Hec. | Bandhwa 3.340 Hec. |
| Water holding capacity | Kho Kho 2.25 Lakh $M^3$ | Bandhwa 1.38 lakh $M^3$ |
| | Pahladwa 0.71 lakh $M^3$ | |
| Catchment area | | |
| Land use of catchment | Residential | |
| Authority maintaining the water body | Municipal Corporation and Private | |
| Current use of water body | General use, irrigation, religious | |
| Current status | Unhealthy, polluted | |
| Associated problem of water body | Pollution, silting, encroachement | |
| Remedial measures | Desilting, Water quality improvement | |

**D. Sarona Talab**

| | |
|---|---|
| Name of the Water | Sarona Talab (Shiv Sagar) |
| Locality | Sarona Villave |
| Period of construction | 1850 |
| Constructed by | Thakur Gulab Singh |
| Purpose of construction | Religious |
| Owner of water body | Nahar Singh Thakur |
| Source of water | Rain water |
| Water spread area | 2.350 Hectare |
| Water holding capacity | 0.55 lakh $M^3$ |
| Catchment area | |
| Land use of catchment | Partly residential |
| Authority maintaining the water body | Shri Nahar Singh Thakur |
| Current use of water body | General use, religious |
| Current status | Unhealthy, polluted |
| Associated problem of water body | Water pollution, silting |
| Remedial measures | Desilting, Ghat reconstruction, lighting |

**E. Machi Talab**

| | |
|---|---|
| Name of the water body | Machi Talab |
| Locality | Gudhiyari |
| Period of construction | 1889 |
| Constructed by | Ancestors of Ramkrishna Dani |
| Purpoe of construction | General use, religious |
| Owner of water body | Private |
| Source of water | Rain water, drain water |
| Water spread area | 2.730 Hectare |
| Water holdong capacity | 0.46 lakh $M^3$ |
| Catchment area | |
| Land use of catchment | Residential area |
| Authority maintaining the water body | Private |
| Current use of water body | General, irrigation, religious |
| Current status | Unhealthy, polluted |
| Associated problem of water body | Pollution, silting, encroachment |
| Remedial measures | Protection, desilting, ghat improvement, lighting |

**F. Ama Talab Group** (Dhobi Talab, Ama Talab, Ghorahi Talab, Ramkund Talab)

| | | |
|---|---|---|
| Name of the water body | Ama Talab Group | |
| Locality | Between Ramkund, Samta Colony | |
| Period of construction | 1670 | |
| Constructed by | | |
| Purpose of construction | General use | |
| Owner of water body | Dhobi Talab - Government, Others - Private | |
| Source of water | Rain water, drain water | |
| Water spread area | Dhobi Talab | 1.214 Hectare |
| | Ama Talab | 2.950 Hectare |
| | Ghorahi Talab | 3.040 Hectare |
| | Ramkund Talab | 2.230 Hectare |
| Water holding capacity | Dhobi Talab | 0.40 lakh $M^3$ |
| | Ama Talab | 0.88 lakh $M^3$ |
| | Ghorahi Talab | 0.74 lakh $M^3$ |
| | Ramkund Talab | 0.39 lakh $M^3$ |
| Catchment area | | |
| Land use of catchment | Encroachment by residential jhuggis | |
| Authority maintaining the water body | Private | |
| Current use of water body | General, Washing clothes | |
| Current status | Unhealthy, polluted | |
| Associated problem of water body | Pollution, silting, encroachment | |
| Remedial measures | Protection, desilting, water quality improvement | |

**G. Budha Talab**

| | |
|---|---|
| Name of the water body | Budha Talab |
| Locality | Budhapara |
| Period of construction | 10th Century |
| Constructed by | Raja Brahma Dev |
| Purpose of construction | General use, recreational, religious, aquaculture |
| Owner of waterbody | Raipur Municipal Corporation |
| Source of water | Rain water, drain water |
| Water spread area | 30.250 Hectare |
| Water holding capacity | 8.91 lakh $M^3$ |
| Catchment area | |
| Land use of catchment | Encroachment |
| Authority maintaining the water body | Raipur Municipal Corporation |
| Current use of water body | General use, recreational, religious |
| Current status | Unhealthy, polluted |
| Associated problem of water body | Pollution, silting, encroachment |
| Remedial measures | Protection, desilting, water quality improvement |

MAHARAJ BANDH TALAB

**H. Maharajbandh Talab**

| | |
|---|---|
| Name of the water body | Maharajbandh Talab |
| Locality | Downstream of Budha Talab |
| Period of construction | 1770 |
| Constructed by | Maharaj Dani |
| Purpose of construction | General use, recreational, religious, aquaculture irrigation |
| Owner of waterbody | Raipur Municipal Corporation |
| Source of water | Rain water, drain water |
| Water spread area | 23.050 Hectare |
| Water holding capacity | 5.61 lakh $M^3$ |
| Catchment area | |
| Land use of catchment | Encroachment |
| Authority maintaining the water body | Raipur Municipal Corporation |
| Current use of water body | General use, recreational, religious |
| Current status | Unhealthy, polluted |
| Associated problem of water body | Pollution, silting, encroachment |
| Remedial measures | Protection, desilting, water quality improvement |

**Traditional water harvesting system**

The ponds in and around Raipur city are a part of history, and there is a noble cause behind their existence. They enlighten us about the ability and vision of the then planners and administrators. The ponds in Chhattisgarh region are part of traditional water harvesting system. This system has very intelligently integrated the forces of nature, which are responsible for its existence.

Let us try to analyse what are the forces of nature that the then administrators may have taken into consideration to successfully construct such a large number of ponds in Chhattisgarh region. The main factors are: (a) rainfall, and (b) suitable soil formation to retain the rainwater. Chhattisgarh receives mean annual precipitation of around 1100 mm, annually. The major geological formations exposed in this region are limestone and shale. These formations occur in alternate sequence of limestone (Charmuria) - shale (Gunderdehi) - limestone (Raipur) - shale & sandstone (Deodongar), in order of superposition.

The topmost formation of shale and sandstone occurs throughout the Chhattisgarh region, characterised by its yellow colour. In local parlance it is termed as "chhuhi mitti". This soil is impermeable, i.e. it does not let water pass through it, and helps in water retention due to lack of interconnected pore spaces and low permeability. This has also led to heavy losses in drilling costs, wherever drilling a borehole is tried in any such locality. Such land is unsuitable for crop sowing, as it remains waterlogged. The then workers have understood this aspect of the soil, and started using it for retention of surface water.

Now that they have understood the water retention property of yellow shale, what would have been the governing factor/logic to construct the ponds and their location ? The rainfall was concentrated mainly in the monsoon season, with non-monsoonal showers. This has led to a situation of enough water for six months, during and after monsoon shower and scarcity in non-monsoonal season. This must have made them think of conserving the rainwater. What would have been the criteria for site selection to construct the water conserving structures ? Now with the help of toposheet, contour map aided with geological information it is possible for us to reach to the conclusion that; the location of pond sites is based on consideration of (a) thickness of yellow shale cover, and (b) topography of the region.

The contour variation in and around Raipur city is from 270 m to 300 m. The physiographic variation in land surface is termed to be as rolled topography. In cross section is appears to be as a sinusoidal waveform. On plotting geological cross section, it is evident that yellow shale occurs on top, from 290 m and above which is underlain by limestone. This leaves with a margin of more over 10 m to construct a water conservation structure.

Another interesting condition in Raipur city is that, when we plot the location of the ponds in the Raipur city, step like pattern is noted in compliance with the extent of area where yellow soil is exposed and the ground elevation. This definitely needs a deeper sense of understanding and appreciation of the knowledge of civil engineering of the then planners. They have very well understood the engineering properties of the soil, its load bearing capacity, and effective storage for unit fall/rise in elevation. This made them wiser in selecting the size of the structure to be constructed. Above all, they have mastered the technique of overflow/spillage lakes. In such structures, successive structures were constructed of specific dimension aligned in the direction of descending elevation. When the rainwater/surface water has filled the structure at highest elevation, water would overflow/spill into the successive structure, and so on, leading to conserve every drop of water flowing towards the stream or river.

**Water Quality**

A reconnaissance survey to evaluate the chemical analysis of water was carried out. The water samples were analysed for pH, electrical conductivity, calcium, magnesium, sodium, potassium, chloride, sulphate and total hardness. The factors taken into consideration for selecting a specific site for water sample collection are topography, geology, land use, proximity to any industry, and in consultation with the local residents. The quality of water was evaluated according to the Standard Methods for the Examination of Water & Wastewater, 17th Edition, prepared and published jointly by American Public Health Association, American Water Works Association, and Water Pollution Control Federation. The results are given in **Table 26.**

| Samples | pH | T,°C | EC, S/cm | Ca | Mg | Na | K | Cl | $SO_4$ | $NO_3$ | $HCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Quarry water | 7.2-8.8 | 34.3-35.2 | 733-995 | 56-124 | 24-140 | 21-27 | 5-20 | 81-176 | 12-19 | 0.1-0.2 | 40-76 |
| Tubewell | 7.6-8.1 | 30.8-34 | 514-1179 | 196-448 | 28-104 | 10-23 | 3-20 | 0-165 | 3-25 | 0.1-0.8 | 36-140 |
| Dugwell | 6.9-7.4 | 30.9-35.9 | 407-1708 | 92-368 | 20-144 | 14-29 | 8-27 | 11-324 | 6-54 | 0.3-0.9 | 52-146 |
| Surface Water | 7.6-8.1 | 30.4-38.2 | 421-1900 | 44-192 | 60-124 | 17-36 | 12-35 | 0-380 | 2-24 | 0.1-1 | 48-216 |

Ta[illegible]. Range of concentration of chemical constituents in water samples from various sources. The physical parameters viz pH, T=temperature of water, E=Electrical Conductivity were measured in-situ. The chemical analysis was carried out in laboratory where Ca=Calcium, Mg=Magnesium, Na=Sodium, K=Potassium, $SO_4$=Sulphate, $NO_3$=Nitrate and $HCO_3$=Bicarbonate. The ions are measured in ppm.

Further, study was carried out on the generation and disposal of urban waste in Raipur city. The three main sources of urban waste generation are domestic, industrial and agricultural. The prevailing practice of includes direct disposal of domestic waste through the sewer line, which opens into the natural drainage system of the area. Septic waste is disposed into soak pits within the highly porous and permeable laterite capping over the limestone. Excessive concentration of detergents, nitrate, organic chemicals, oil & grease bacteria and viruses present the greatest theat to ground water quality.

The large number of industires situated within the municipal limits poses threat to the water quality. As a result of reconnaissance survey carried out in some areas it is evident that the oil extraction units are responsible for variation in pH, total solids, suspended solids, dissolved solids, chloride, alkalinity, BOD, COD, and abnormal increase in oil & grease in groundwater. Due to effluent discharge from the ferroalloys units the groundwater quality shows anomalous values for pH, total solids, suspended solids, dissolved solids, chloride, alkalinity, BOD, COD, and increase in concentration of metallic ions, viz. iron, chromium, nickel, zinc etc. The agro-based industires show variation in pH, total solids, suspended soilids, dissolved solids, chloride, alkalinity, BOD, COD, sodium, potassium, and bioassay. The textile units may pose threat due to increased concentation of pH, total solids, suspended solids, dissolved s·'ids, choride, alkalinity, BOD, COD, colour dyes, and trace metals like chromium.

The prevalent agricultural practices may give rise to concentration of nitrate concentration in groundwater due to application of fertiisers and manure. The excessive use of pesticides may also increase concentration of toxic inorganic solvents in soil and groundwater.

**Effects of landuse on the pond ecosystem functioning**

Decreased soil cover results in decreased infiltration and increased water runoff. Increased use of inorganic fertilizers across the landscape, associated with decreased capacity of the soil community to immobilize nutrients leads to eutrophication of groundwater. The same effects are observed from disposal of high-N manure from intensive livestock production.

Encroachment of wetlands may be a major source of $CO_2$ emission from oxidation of large stocks of organic matter. Methane is generated from anaerobic decomposition of wetlands, and increases in the area of permanently and non-permanently flooded rice cultivation are through to account for a significant proportion of the increase in net $CH_4$ emissions.

The presence of surface aquatic cover, water hyacinth, results in leafy cover over the pond surface, which decreases the evaporation but greatly increases the transpirational losses. The net balance between the two can alter the water levels. The differences in the depth of rooting zones, and thus of water use, result in differences in the depth of carbonate deposition.

Biodiversity effects on groundwater flux (especially the presence of phreatophytes in the vegetation) are predicted to be important in almost any terrestrial system where precipitation exceeds potential evapotranspiration and there is significant flow of water from the soil profile into the groundwater.

## Conclusions

Although there is little specific documentation about the importance of biodiversity components affecting biotic linkages and the ecosystem processes. Review of the available information indicates that a common outcome of human impacts on biotic linkages is alteration of the stability of community structure and composition. A detailed multidisciplinary study on the biotic linkages, identification of species and its genetic variability, cross - biome comparison is desperately needed.

First and foremost need is to protect the ponds. The indiscriminate and unscientific use of ponds for various purposes must be prohibited. The aesthetic value of the ponds must be restored. No doubt it requires financial inputs that has to be borne by the society, as it will be the main beneficiary.

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RIVER KHARUN