नमामि गंगे

QUALITY COUNCIL® OF INDIA
Creating an Ecosystem for Quality

REPORT ON
CENSUS SURVEY OF WATER BODIES
UTTARAKHAND

QUALITY COUNCIL® OF INDIA

Creating an Ecosystem for Quality

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Chairman,
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The Ganga is a conduit for spirituality and faith for the people of India. To preserve and rejuvenate this sacred entity, the National Mission for Clean Ganga (NMCG) was instituted by the Ministry of Jal Shakti, and it has been an honour for QCI to collaborate with the Ministry for the mission.

Given the severe inequality of access to clean drinking water, which disproportionately impacts India's most vulnerable and marginalised communities, the mandate entrusted to the NMCG has become ever more important.

With India's ponds, reservoirs and other water bodies drying up, the Government of India highlighted the need for an accurate data on the number of water bodies existing in the villages within the Ganga basin. QCI took up the responsibility to address this critical gap along with the NMCG. This led us to undertake the Census Survey of Water Bodies.

Through this project, we made sure to collect most accurate data throughout the assessment, which lasted 140 days. A team of 41 assessors evaluated a total of 2,569 villages and mapped 1,100 water bodies in the Ganga basin, through which we derived 23,100 data points.

Owing to the norms of COVID-19 pandemic, we made sure that our processes were digitalised to ensure maximum coverage. This led us to collect geo-tagged picture-based evidence with approximately 1,49,346 pictures received.

Our past experiences in working with the government ministries have indicated that an in-depth study of data unveils useful information and provides a greater insight into any issues that exist. Hence, this project's highlight was “Drone-based assessment”. Through this, water bodies were geo-mapped to calculate certain parameters like size, depth and circumference of the water bodies within the Ganga basin present in four states namely, Uttar Pradesh, Bihar, Uttarakhand and Jharkhand.

Due to geo-mapping and tagging, the Ministry can now track the water bodies across the Ganga districts through a unique identity given to them. This makes each water body accessible to districts so that they can take necessary measures at village level.

This resulted in an impressive methodology, making the assessment more holistic as well as accurate. Also, it was made sure that the best practices were paid attention to, thoroughly.

I would like to congratulate all for putting their best foot forward in preserving this sacred symbol. Let's keep our collective efforts of working on this cause of keeping the water bodies safe and clean. Remember, this is just one step of making India healthier, brighter and better each day. Jai Hind!

DR. RAVI P. SINGH

Secretary General,
Quality Council of India

Ganga is a symbol of faith, culture and hope for the people of India as well as a major source of irrigation, agriculture, employment and electricity across the nation. Keeping the social, religious and economic aspects of the river in view, the National Mission for Clean Ganga (NMCG) was launched by the Ministry of Jal Shakti. It is a delight to note that the Ministry entrusted Quality Council of India with the responsibility of conducting its detailed study of the inland water bodies situated in villages of five states – Uttar Pradesh, Bihar, Uttarakhand, Jharkhand and West Bengal.

When we speak about conservation and preservation of water resources in developing nations, we make sure there are positive steps being implemented for the development of water bodies and, in turn, betterment of local communities and shelters depending on them. While conducting the study, it was brought to our notice that many villages lacked ecosystem benefits from the water bodies due to its inaccessibility and contamination. It was imperative for us to conduct this study as undertaking the Census not only highlighted the underlying importance of water resources and conservation of clean drinking water but also provided a real chance at improving the lives of several Indian communities relying on the river Ganga for livelihood in a tangible way.

While conducting the survey, QCI faced several challenges. Be it the COVID-19 pandemic or the massive landslides and floods in Chamoli district of Uttarakhand – these led to a delay in the beginning of the assessment process. The inaccessibility to several villages in many states stood as another major challenge.

However, with great support provided to the team by the Ministry. The team tackled all the issues very mindfully. Several inaccessible villages in many states were later covered with the help and support of the locals. We also formed a special group that visited the villages of Chamoli for assessment of water bodies considering the severity of the situation.

Today, it is a pleasure to announce that a team of 41 assessors engaged in the functioning of this project, including conducting the surveys, analysing the gathered data and recommending remediation for conservation, beautification and preservation of the water bodies. We could gather approximately 23,100 data points over the course of 140 days of rigorous research and assessment, covering 2,569 villages and mapping 1,100 water bodies in Ganga basin. The on-ground assessment methodology was framed in a way that it brought the real picture of water bodies to our notice via assessors. This is how we recommended the best remedial measures for the revival/replenishment of water bodies according to their condition.

I would like to thank the Ministry for providing us with enough resources and assistance to work for an initiative of great national importance and development. QCI would like to extend its support in further times for such initiatives as well. We believe that when India's water bodies will be clean, its communities will shine even brighter!

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Glossary

Aesthetic Enhancement	Park, benches, floral beautification, footbridge, structure/statues around the water body region.
Biological Remediation	Use of microbes or plants such as canna, Cyprus or any suitable plant and (Another method: Geo-Netting) to clean up contaminated water body, soil and groundwater. It is recommended in order to keep Water body peripheral ecosystem robust.
Blockage mapping	Mapping of roads and drains in around the water body blocking the drainage flow
Catchment Area	An area of land where water collects when it rains finding its way into streams and down into the soil, eventually feeding the water body.
Catchment Yield	The total quantity of surface water that can be expected in a given period from a stream at the outlet of its catchment is known as yield of the catchment in that period[1].
Contour Mapping	Delineation of any property in map form by constructing lines of equal values of that property from available data points[2].
Defunct Borewells	Borewells that are no longer in purpose due to reduced groundwater levels.
Domestic Wastewater Secondary Treatment Plant	Secondary treatment is the removal of biodegradable organic matter (in solution or suspension) from wastewater through a series of chamber consisting of Sand charcoal or Activated carbon and Coarse gravel at the edge of the water body entrance. The aim is to achieve a certain degree of effluent quality of wastewater. This is achieved with physical phase separation to remove settleable solids followed by a biological process to remove dissolved and suspended organic compounds.
Drainage Basin Alteration (Contour Bunding)	Geographical method such as slope modification, contour bunding, construction of trenches, terracing for protection against soil/wind erosion and restoring water quality and quantity.
Drainage runoff	Flow of wastewater into the water body
Dredging	Process of removal of silt and other material deposited at the bottom of the water body as a result of drainage or run off.

[1] www.theijes.com

[2] Contour mapping | geography | Britannica

Eutrophication	Gradual increase in the concentration of phosphorus, nitrogen, and other plant nutrients causing structural changes to the aquatic ecosystem such as: increased production of algae and aquatic plants, depletion of fish species, general deterioration of water quality and other effects that reduce and preclude use
Green Buffer zone	Area that is created or demarcated to enhance the protection of a specific sensitive conservation area, often peripheral to it from negative external pressures. These areas in the context of water body will act as a filter on nutrients in the underground water and surface water.
Leachate	Toxic liquid that is formed from the breakdown of wastes at the landfill area that percolate into the ground.
Non-Point Source Pollution	Nonpoint source pollution refers to water pollution from diffuse sources. It negatively influences water bodies from sources such as polluted runoff from agricultural areas draining into a water body. Nonpoint source pollution may derive from many different sources with no specific solution able to rectify the problem, making it difficult to regulate. It is therefore difficult to control because it comes from everyday activities, such as fertilizing a lawn, using a pesticide, or constructing a road or building.
Open Defecation	Human practice of excreting in the open in fields, bushes, forests, streets, canals, waterways, ditches, or other open areas.
Orthomosaic Images	A geometrically correct aerial image that is composed of many individual overlapping still images that are stitched together[3].
Oxygen Saturation levels	Oxygen saturation is a ratio of the concentration of "dissolved oxygen", to the maximum amount of oxygen that will dissolve in that water body, at the temperature and pressure, which constitute stable equilibrium conditions.
Riparian Vegetation	An interface area between land and water body that slows and dissipates floodwater, prevent erosion and ensures high water quality of water body.
Settlement/ Encroachment	Development on waterbodies and buffers areas around them encompassing removal of vegetation, or an alteration of topography, consequently impacting the functions and values in such natural areas such as a decline in water quality, loss of habitat (both aquatic and terrestrial), disruption of equilibrium (or naturally stable) conditions, loss of flood attenuation, or reduction of ecological processes.

[3] Orthomosaic Map

Silt Management	Measures adopted to trap the silt before entering the water body by digging trenches in the catchment area.
Sludge Management	Processes and technologies that
Total Dissolved Solids	Total dissolved solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions[4].
Total Suspended Solids	Total Suspended Solids (TSS) refers to any particles that are suspended in the water column. These particles can include silt, algae, sediment, and other solids floating in the water (both organic and inorganic). These particles are defined as being large enough to not pass through the filter (through the filtration process) used to separate them from the water. Suspended solids absorb heat from sunlight and as a result, the water temperature increases resulting in a deprivation of dissolved oxygen in the water, which can be disastrous to aquatic life if levels are too high. TSS can be measured in ppm, mg/L, g/L and %[5].
Turbidity	Turbidity is the amount of cloudiness in the water varying from a river full of mud and silt where it would be impossible to see through the water (high turbidity), to a spring water which appears to be completely clear (low turbidity).
Waste weir	A waste weir is a slatted gate on each canal level or pound, to remove excess water and to drain the water for repairs. This differs for a reservoir, for which a waste weir is another name for a spillway, i.e. not having the boards to adjust the water height nor the paddles to drain all the excess water.
Wastewater drainage	Used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff, and any sewer inflow or sewer infiltration.
Water body – Natural and Artificial	Natural water body means a pond, spring or stream that was historically present in a natural state but may have been physically altered over time. Artificial water bodies are man-made water bodies such as Kunds, Irrigational reservoir and a pond constructed for occupational use.
Water Body Peripheral Ecosystem	Geographic area or near the periphery of a water body where plants, animals, and other organisms, as well as weather and landscape, work together to make the ecosystem robust.

[4] WHO

[5] TSS

Water Hyacinth/ Duckweed	Water hyacinth is a free-floating perennial invasive aquatic plant, highly popular due to its beauty and ability to absorb excess nutrients from the pond in order to control and conserve environmental condition. It can absorb excess minerals and inorganic substance from wastewater entering into a water body. Duckweeds are the smallest flowering plants known which has a property to purify water. It also maintains the habitat by providing enough shade to keep the growth of oxygen-robbing algae down.

Abbreviations

NMCG	National Mission for Clean Ganga
QCI	Quality Council of India
CSWB	Census Survey of Water Bodies
CAPI	Computer-Assisted Personal Interviews
DGCA	Directorate General of Civil Aviation
DM	District Magistrate
ADM	Additional District Magistrate
SDM	Sub-Divisional Magistrate
DFO	District Forest Officer
DPRO	District Panchayati Raj Officer
DO	Direct Observation
OD/OU	Open Defecation/Open Urination
DM	Depth Measurement
KII	Key Informant Interview
WBD	Water Body Details/Documents
CF	Citizen Feedback
CT/PT	Community Toilet/Public Toilet
SLWM	Solid Liquid Waste Management
SONAR	Sound Navigation Ranging
NABCB	National Accreditation Board of Certification Authorities
IB	Inspection Bodies
DTM	Digital Terrain Model
DSM	Digital Surface Model
GVP	Garbage Vulnerable Points
SWM	Solid Waste Management

1. EXECUTIVE SUMMARY

'Census Survey of Water Bodies (CSWB) in Ganga basin' under 'Namami Gange' encapsulated 100 per cent mapping of the water bodies across 31 districts (3,189 villages) spread across Uttar Pradesh, Uttarakhand, Bihar, Jharkhand and West Bengal. With challenges abound, one of the major ones being geo-tagging of the water bodies, the National Mission for Clean Ganga (NMCG) entrusted the Quality Council of India (QCI) for assisting it with the quest of assessing all water bodies and create a baseline data for all the 31[6] Ganga districts.

The three main objectives of this study were to (a) map the water bodies present in villages, (b) assign a unique code to the water bodies for identification and (c) formulate Water body Cleanliness Index. The identified thrust area includes all water bodies in the Ganga district, which are either dried-up or have water less than their full water holding capacity. This survey includes two major components:

- Identification & Mapping: QCI leveraged the network of National Accreditation Board for Certification Bodies (NABCB) accredited inspection bodies in conducting the survey through Computer-Assisted Personal Interviews (CAPI). It involved 2 sub-components (a) Key Informant Interview, and (b) Direct Observation.
- Estimation of water holding capacity: In order to acquire size, depth and volume of the water bodies the aerial survey using drones and floating depth measurement device were used. The aerial survey provided precise physical properties of the water bodies taking into account the area, periphery, vegetation, settlement and additionally, depth of dried-up water bodies from orthomosaic images and contour maps.

The total number of villages allocated and the total number of water bodies found are mentioned in the table below:

Description	Uttar Pradesh	Jharkhand	Bihar	Uttarakhand	West Bengal	Total
Total number of villages allocated	691	66	220	222	1990	3189
Total number of water bodies found	329	56	113	44	558	1100

Table 1: Survey figures

[6] Districts covered under 'Jal Shakti Abhiyan' were excluded from the survey, which brought down the number of districts from 52 to 31 in five Ganga states. Two districts in West Bengal: Howrah and Murshidabad were not covered, as official permission were not granted for the survey of the waterbodies in these districts. Several villages in Malda district did not exist in their respective Gram Panchayats. This concomitantly reduced the total number of villages actually assessed during the survey.

Through the study, it is concluded that the water bodies in villages of Uttarakhand tops the chart among the five states with an average score of 200.63. While, Bihar with an average score of 164.43 ranked last.

The study is followed with the creation of dashboard for data visualization and pictorial representation of all the five states including the district, block and village level data, which includes layered maps and static data of the water bodies. The CSWB not only provides a full database of water bodies but also provides appropriate measures and recommendations for rejuvenation of the water bodies present in the villages of five Ganga states.

The geospatial data of all the water bodies in selected 5 states has been stored and displayed in the dashboard which has been collected and processed using a drone and on-field assessments. The data has been visualized in a flow such as National- State- District- Block- Village- Water body with assessment photographs.

Following data will be visualized in the dashboard:

1. Category of the water body
2. Scores of the water body
3. Water body Cleanliness Index
4. Water body-wise codes
5. Volumetric assessment[7] data (Water holding capacity)
6. Satellite/Map view of the water bodies

This data will be accessed by district administration in each of the 5 states. The district officials can view the recommendations and undertake action based on the data in the portal and thereafter upload the 'Action Taken' status data, which includes few text fields and photographs, against each waterbody.

7. It was a cumbersome process for our team to get approval for flying a drone in West Bengal. Our team went on-field to get the required permissions from the respective District offices but drone approval could not be obtained due to lack of cooperation.

2. RESEARCH METHODOLOGY

The deliverables of the assessment were structured in two phases, as the 'On-field assessment' followed by the 'Drone assessment'.

The On-field assessment assisted in determining current health of the water bodies and helped in understanding the socio-economic values that these water bodies hold within the local communities.

The second phase of assessment was achieved through an Ariel survey by using drone technology that demarks the physical properties and surrounding structures of a water body. Properties of a water body like its peripheral, area, volume/depth and surrounding terrains were easily fetched with the help of drones without compromising on the quality and accuracy. The aerial survey was conducted as per the approval by NMCG and in compliance with the DGCA guidelines.

The following table depicts the total number of Districts, Blocks, Gram Panchayats and Villages covered under the CSWB assessment in five Ganga States:

State	District	Block	Gram Panchayat	Villages
Bihar	6	28	119	219
Jharkhand	1	6	26	66
Uttar Pradesh	11	50	435	689
Uttarakhand	7	30	130	222
West Bengal	4	28	128	1373
Total	**29**	**142**	**838**	**2569**

Table 2: Sample size of the survey

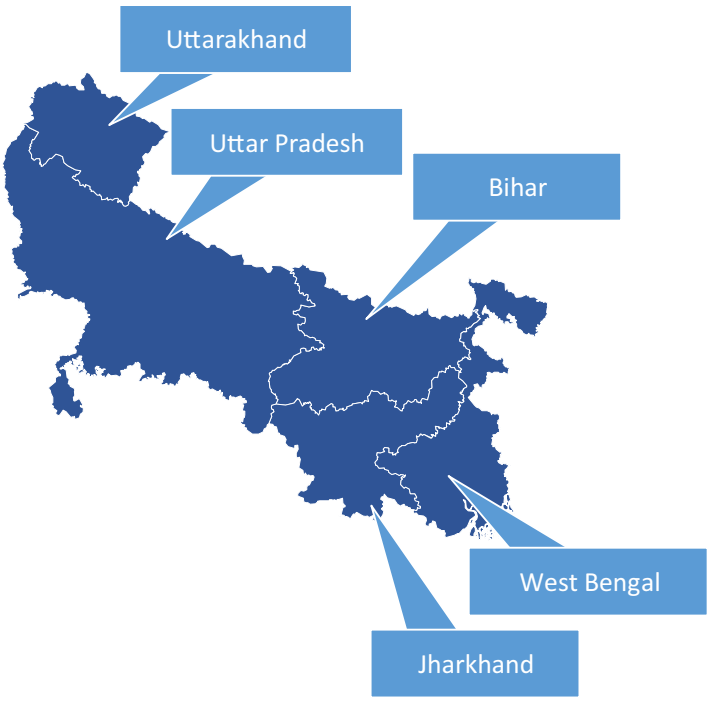

Figure 2.1. : Surveyed Ganga states

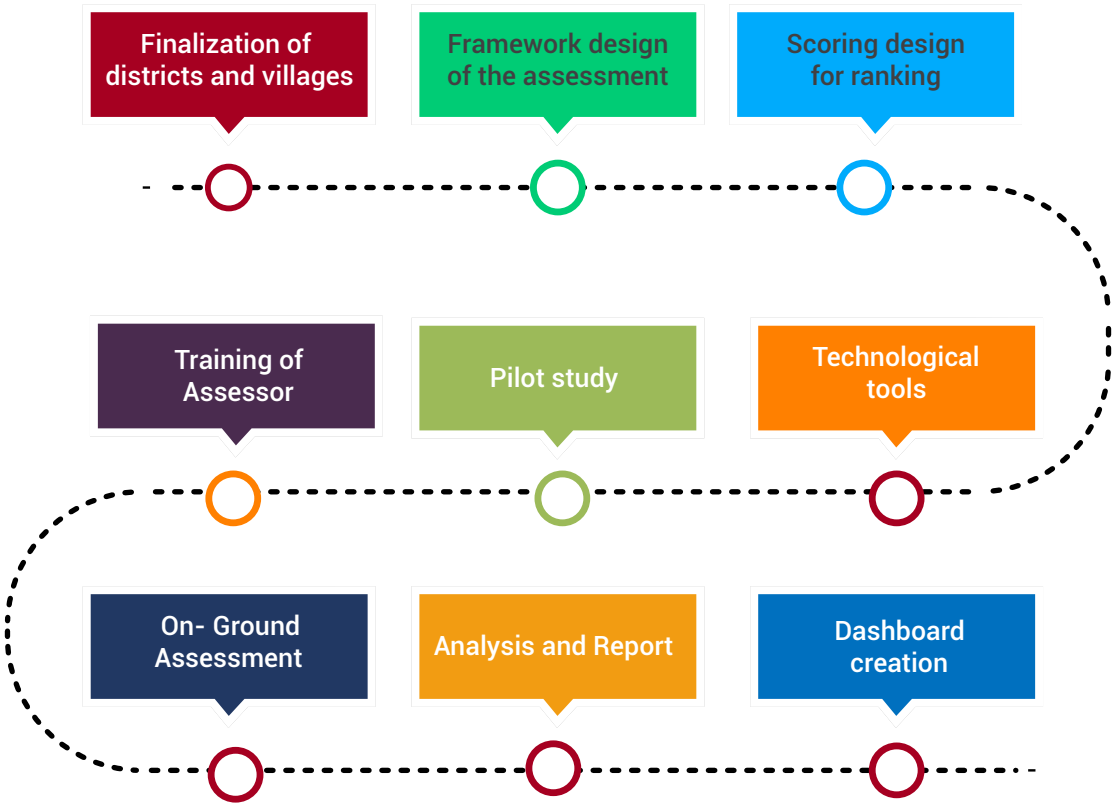

Figure 2.2. : Project Methodology

Step 1: Finalization of District and Villages for assessment

Initially, QCI was allocated 31 districts in 5 Ganga states for the assessment but due to various limitations[8] only 29 districts could be covered.

Step 2: Framework design of the assessment

Process followed for the development of 'Assessment Framework':

1. In order to begin with the survey of the water bodies, all probable stakeholders were identified to derive a holistic view from the assessment. Our stakeholders included DMs, ADMs, SDMs, DFOs, DPROs, Pradhans, Tehsildar, Patwari, Lekhpal and village locals at Village and Gram Panchayat level and District levels.
2. Detailed questionnaires were prepared in consultation with NMCG. The questionnaires consisted the following sections-
    a. **Direct Observation (DO):** The on-field assessors provided a status and health of the water bodies as perceived on the following parameters of Condition/ State, Infrastructure, Aesthetics, Quality, Solid Waste, Wastewater, and OD/OU.
    b. **Depth Measurement (DM):** Average depth of a water body from all cross-sectional areas were found out by subdividing the water bodies into 4 checkpoints. Depending on the size of the water body either 4 or 6 checkpoints were defined and 4 throws were made from each cross-sectional area using depth measurement meter. Over all 16-24 repetitive observations were made in order to ensure data accuracy of average depth.
    c. **Key Informant Interviews (KII) and Citizen Feedback (CF):** To validate the information received during on-ground assessment of water bodies, the authorized government official at the village, panchayat or at the block level issued an undertaking. Verbatims were taken from the identified stakeholders as a double confirmation about availability and actual status of water bodies along with the problems that had been addressed by the villagers using CAPI.
    d. **Water Bodies Details/ Documents (WBD):** Reviewed the documents (subject to availability) received from the village officials on utility benefits gained by locals, cleaning, spread-out area, storage capacity and various other critical information about water bodies.

Step 3: Scoring design for ranking of States, Districts and Blocks

On-ground assessment of the water bodies was conducted on the basis of various key indicators such as Condition/State, Infrastructure, Aesthetics, Quality, Solid waste, wastewater management, and OD/OU. A weightage against each of these was evaluated as a part of scoring. These key indicators formed the 'Water body Cleanliness Index' based on which the Ganga districts and their respective blocks are ranked.

[8]. Refer 'Project Challenges'

Category	Sub-category	Question Wise Marks	Total	Section Total
Water Body Cleanliness Index	Condition/ State	Adequacy	10	40
		Settlement	20	
		Septic tanks	10	
	Infrastructure	Condition of fencing	20	50
		Outlet	10	
		Road connected to water body	10	
		CT/PT	10	
	Aesthetics	Aesthetic enhancement	10	10
	Quality	Turbidity	10	50
		Eutrophication	20	
		Foam	20	
	Solid Waste	Waste Inside	20	80
		Leachate	20	
		Waste Around	20	
		Dustbins	10	
		Flies	10	
	Wastewater	Washing around water body	20	50
		Drainage present	30	
	OD/OU	Faecal matter around water body	20	20

Table 3: Summary of Scoring Toolkit

Descriptors	Intervals	Maximum Range	Minimum Range
Best	300.00-240.00	300.00	240.00
Good	239.99-180.00	239.99	180.00
Average	179.99-120.00	179.99	120.00
Poor	119.99-60.00	119.99	60.00
Very Poor	59.99-0.00	59.99	0.00

Table 4: Water body Cleanliness Index

Intervention Methodology

Type Of Water Body	Particulars	Sub - Parameter	Recommendation	Intervention
Eutrophication	Physical infrastructure	Fencing	Bio fencing required	High
			Wooden/vinyl required	Medium
			Barbed wires/small-metal/ cemented	Low
		Road	-	-
			Drains and roads are blocking the flow of Water Bodies	Medium
			Periphery of water body	Low
	Drain Mapping	Drainage	Black water flow	High
			Grey water flow	Medium
			Other water or no drain found	Low
		Bar screen	Drainage pipes directly connected to water body	High
			No screen/net-mesh/grill found	Medium
			-	Low
	Catchment area	Agriculture fields/Habitat	Agriculture fields or habitat found	High
			-	-
			Both agriculture fields and habitat not found	Low
		SLWM	Solid waste found on the surface of water body	High
			Solid waste present around the water body	Medium
			No solid waste found	Low
		SLWM (Animal waste)	Cattle waste/dung found	High
			-	-
			-	-
	Inner structure	Dredging	Needs to be done for 04 metre (approx.)	High
			-	-
			-	-
		Pal/berms	Not found for big size water body	High
			Not found for small size water body	Medium
			Found on the circumference of water body	Low
		Inlet	Not present	High
			Present but needs the required shape	Medium
			-	-

Type Of Water Body	Particulars	Sub - Parameter	Recommendation	Intervention
	Sustainability plan	Biological remediation	Designing of floating treatment wetland	High
			-	-
			-	-
		Filtration	Rain/storm water mapping and cleaning process	High
			-	-
			-	-
		Rotation of cleaning	Preferably each year	High
			-	-
			Happening within 6 months	Low
		Eutrophication prevention	Removing the Eutrophied water and cleaning the water bed	High
			-	-
			-	-
		Utility benefits	No data provided	High
				-
				-
Healthy	Physical infrastructure	Fencing	-	-
			Bio fencing required	Medium
			Wooden/vinyl or Barbed wires/small-metal/cemented	Low
		Road	-	-
			found on the circumference of water body	Medium
			If drains and roads are blocking the flow of water body	Low
	Drain Mapping	Drainage	-	-
			Black water flow	Medium
			Grey water or Other water or no drain found	Low
		Bar screen	-	-
			Drainage pipes directly connected to water body	Medium
			-	-

Type Of Water Body	Particulars	Sub - Parameter	Recommendation	Intervention
Healthy	Catchment area	Agriculture fields/Habitat	-	-
			Agriculture fields or habitat found	Medium
			Both agriculture fields and habitat not found	Low
		SLWM	-	-
			Solid waste found on the surface of water body	Medium
			Solid waste present around the water body or No solid waste found	Low
		SLWM (Animal waste)	-	-
			Cattle waste/dung found	Medium
			-	-
	Inner structure	Dredging	-	-
			-	-
			Clearing the mud/silt from the bottom of the water body	Low
		Pal/berms	-	-
			Not found for big size water body	Medium
			Not found for small size water body or found on the circumference of water body	Low
		Inlet	-	-
			Not present	Medium
			Present but needs the required shape	Low
	Sustainability plan	Biological remediation	-	-
			-	-
			Preventing from Non-Point source pollution	Low
		Filtration	-	-
			-	-
			Rain/storm water mapping and cleaning process	Low
		Rotation of cleaning	-	-
			Preferably each year	Medium
			Happening within 6 months	Low

Type Of Water Body	Particulars	Sub - Parameter	Recommendation	Intervention
		Eutrophication prevention	-	-
			-	-
			Not Eutrophied	Low
		Utility benefits	-	-
			No data provided	Medium
			-	-
Water Hyacinth	Physical infrastructure	Fencing	Bio fencing required	High
			Wooden/vinyl required	Medium
			Barbed wires/small-metal/ cemented	Low
		Road	-	-
			-	-
			Found on the circumference of water body or If drains and roads are blocking the flow of water body or No road found	Low
	Drain Mapping	Drainage	Black water flow	High
			Grey water flow	Medium
			Other water or no drain found	Low
		Bar screen	Drainage pipes direct connect to water body	High
			No screen/net-mesh/grill found	Medium
			-	-
	Catchment area	Agriculture fields/Habitat	Agriculture fields or habitat found	High
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			-	-
	Inner structure	Dredging	Needs to be done for 04 metre (approx.)	High
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Type Of Water Body	Particulars	Sub - Parameter	Recommendation	Intervention
		Pal/berms	Not found for big size water body	High
			Not found for small size water body	Medium
			Found on the circumference of water body	Low
		Inlet	Not present	High
			Present but needs the required shape	Medium
			-	-
	Sustainability plan	Biological remediation	Designing of floating treatment wetland	High
			-	-
			-	-
		Filtration	Rain/storm water mapping and cleaning process	High
			-	-
			-	-
		Rotation of cleaning	Preferably each year	High
			Happening within 6 months	Medium
			-	-
		Eutrophication prevention	-	-
			Removing the hyacinth by thrashing and cleaning the water bed	Medium
			-	-
		Utility benefits	No data provided	High
			-	-
			-	-
Dried up	Physical infrastructure	Fencing	Bio fencing required	High
			Wooden/vinyl required	Medium
			Barbed wires/small-metal/ cemented	Low
		Road	Found on the circumference of water body	High
			If drains and roads are blocking the flow of water body	Medium
			No road found	Low
	Drain Mapping	Drainage	Black water flow	High
			Grey water flow	Medium
			Other water or no drain found	Low
		Bar screen	Drainage pipes direct connect to water body	High
			No screen/net-mesh/grill found	Medium
			Other water or no drain found	Low

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			-	-
	Sustainability plan	Biological remediation	-	-
			-	-
			-	-
		Filtration	Rain/storm water mapping and cleaning process	High
			-	-
			-	-
		Rotation of cleaning	Preferably each year	High
			Happening within 6 months	Medium
			-	-
		Eutrophication prevention	-	-
			-	-
			-	-
		Utility benefits	No data provided	High
			-	-
			-	-

Table 5: Intervention Methodology

Step 4: Technology tools

1. **CAPI:** Hand-held devices were used for on-field assessment to capture the responses of the stakeholders based on the final questionnaires. All the evidences were geo-tagged with date and time stamp for real-time data quality check. Geo-tagged location facilitated the drone pilots in identifying water bodies for aerial survey.
2. **Depth measurement device:** A Floating device based on SONAR technology was used to capture the depth of water bodies for 'Volumetric assessment'. The Depth measurement device was a set of two devices: (a) Part flows on the surface of the waterbody and measures the depth of the waterbody through ultrasonic waves and (b) depth measurement meter, a hand-held device which displays the depth readings.
3. **Drone technology:** Drone technology was used to capture high- resolution images, final-scaled geo-positioned orthomosaic images with demarcations, and the contour maps. The drone is operated with a mobile device on a pre-planned path set by the pilot. It hovers over the water body to collect multiple geo-tagged points. Area (in acres) of water bodies were measured through GIS compatible drawing file. Shape files of roads, trees, buildings, farmlands were also produced to measure the distance between closest roads, vegetation or agricultural fields from the water body.

Step 5: Pilot Study

1. To understand the process of water body mapping and ascertaining the framework of the project, a pilot study was conducted in Haridwar district of Uttarakhand and Amroha district of Uttar Pradesh wherein four villages from each district were chosen randomly.
2. Pilot studies for drone assessment were conducted in four villages of Chandauli district of Uttar Pradesh namely Diya, Nagwa, Papraul and Puracheta Dube to test the relevance and efficiency of the framework and survey tools. Corrective measures were taken based on the same before the final Drone assessment.

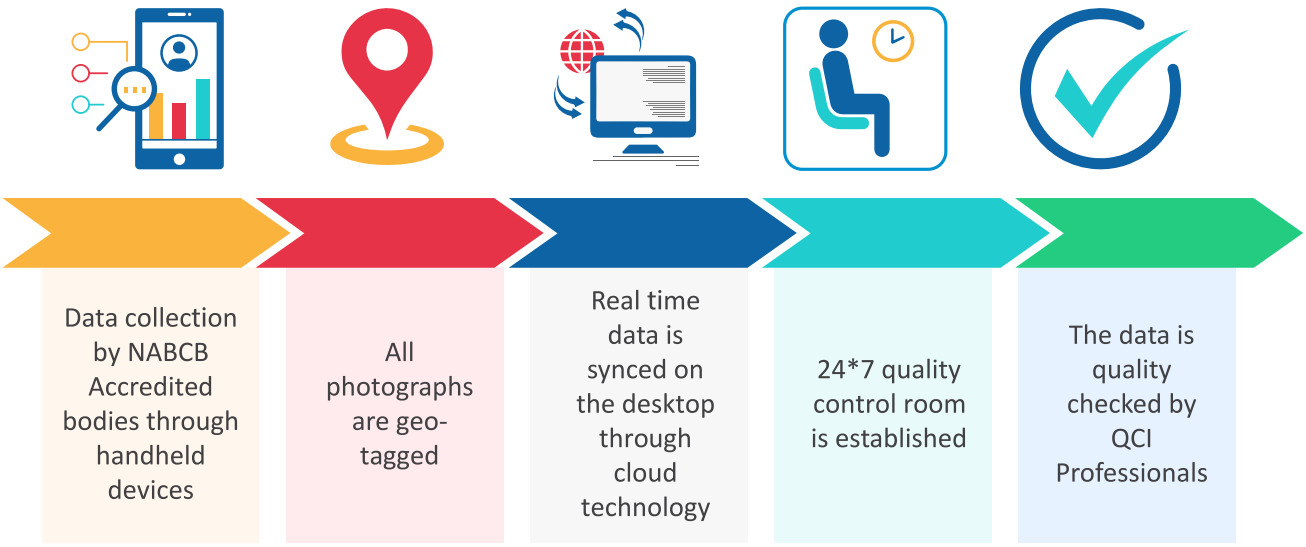
Step 6: Training of Assessor

National Accreditation Board of Certification Authorities (NABCB) certified Inspection Bodies (IBs) were selected based on their relevant experience in the field of assessment and scale of operations. Detailed classroom and field trainings for the assessors were conducted in Kolkata, West Bengal and Bhubaneshwar, Odisha. Thereafter, the assessors were selected on the basis of a test and personal interview.

Step 7: On-ground assessment

The on-ground assessment was carried out in two stages: (a) The first stage involved capturing responses of all stakeholders through personal interviews and evaluation of the water bodies based on the questionnaires using CAPI and depth measurement using the floating device, and (b) In the second stage aerial survey was conducted.

The process of assessment is as below:



Data Monitoring and Control

A 24*7 war room was set up at Delhi office of QCI to monitor the daily progress, consistency and quality of the survey. The survey results were monitored on a real time basis and the queries of the field assessors was resolved promptly by the team through an 'Assessor help desk'.

The data collected by on field assessor underwent a thorough and rigorous three-layer quality checks:

Level 1: Trained assessor collects the data on-ground and uploaded it on a real time basis through mobile application

Level 2: Quality check coordinator (stationed at QCI headquarters) who is mapped to an assessor monitored the survey and validated the information received at the back end.

Level 3: A senior QCI team member at the control room re-evaluated the field data collected

Step 8: Analysis and Report

QCI leveraged the expertise of Indian Statistical Institute in analyzing and interpreting statistical data. Data analysis was carried out using software such as Excel or R.

Step 9: Dashboard creation

A dashboard has been created to display the pictorial data of the key findings of the water bodies in each Ganga basin district. Layered maps include Geo tagged feature, Orthomosiac Map, Contour Map, Ortho Feature map (Circumference, trees, farmlands, residential area), Shape file, Drawing file, DTM, and DSM. Each water body can be identified from their unique codes. The details of all the parameters assessed along with the scores and images of the water bodies could be fetched from the dashboard. Additionally, state of rejuvenation of the water body can also be found. The study has also listed down type of interventions and recommendations for each water body for their protection and rejuvenation which can also be referred from the dashboard.

3. PROJECT CHALLENGES

1. Official support:

Due to on-going COVID and other issues, few district authorities did not cooperate in providing the required permissions for on-ground assessment. Two districts in West Bengal: Howrah and Murshidabad were not covered, as official permission was not granted for the survey of the waterbodies in these districts.

2. Obstacles during Turbidity test and Depth Measurement:

The presence of muddy edges, dense bushes, and thick water hyacinth caused hindrances to collect physical parameters of the water body by the on-field assessors.

3. Drone Approval:

It is a cumbersome process to take the approval for flying a drone. QCI professionals went on the field to get the required permissions from the respective District offices.

4. COVID-19 Pandemic:

Both the first and second wave had disrupted the on-field operations. Many district officials and key informants were reluctant in interacting with the assessors. Covid-19 also led to hike in drone service charges across the nation and non-availability of the desired standard of drones.

5. Natural Hindrances:

The Uttarakhand floods 2021, also known as the Chamoli disaster, began on 7 February 2021. The roads and highways remained blocked and inaccessible to the inspection bodies of our project. As a result, our team members were able to visit Chamoli District for the water body assessment once the situation was under control in the last week of March 2021.

4. ASSESSMENT OVERVIEW: State And District

4.1 UTTARAKHAND

4.1.1 Introduction

A total of 222 villages in 7 districts situated in Ganga basin were covered in the survey conducted in Uttarakhand. However, a total of 44 water bodies were found in 29 Ganga villages of only 4 Districts namely, Chamoli, Dehradun, Haridwar and Rudraprayag during the survey.

Below table depicts the bifurcation of total number of water bodies identified and mapped on the basis of Districts and in their subsequent Block-wise Villages:

District	Number of Blocks	Number of Villages with water bodies	Number of water bodies found
Chamoli	8	17	26
Dehradun	1	1	1
Haridwar	3	10	16
Rudraprayag	3	1	1
Pauri (Garwal)	5	0	0
Tehri Garwal	7	0	0
Uttarkashi	3	0	0
Total	30	29	44

Table 6: District-wise configuration table of Uttarakhand

Only 13 per cent of the villages had water bodies present in them as compared to the total villages assessed in Uttarakhand.

District-wise percentage distribution of water bodies is shown in the graph below:

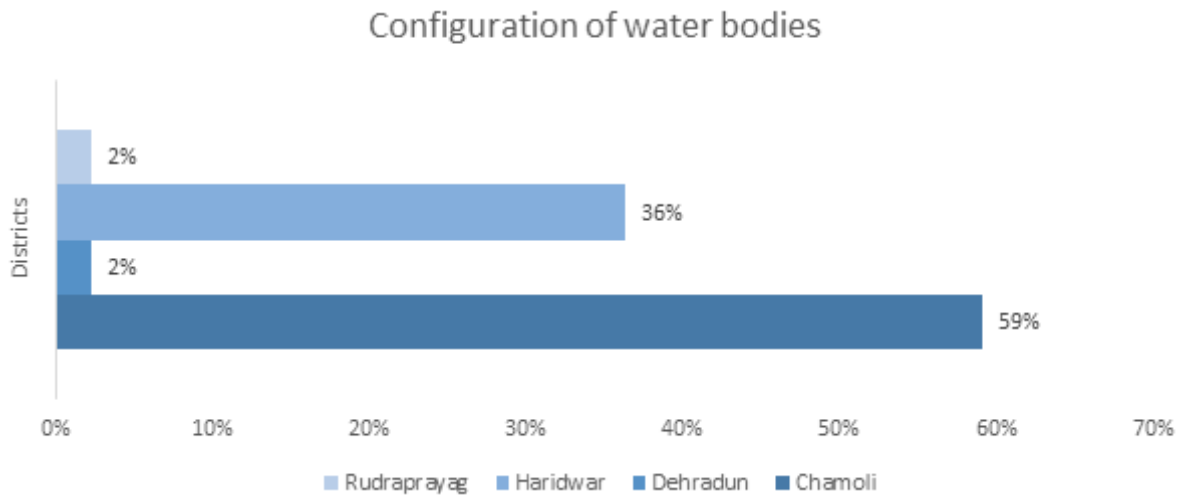


Figure 4.1: District-wise configuration of water bodies

As per the collected data, the Maximum percentage of water bodies were found in Chamoli, which accounted for 59 per cent (26). However, the minimum percentage of water bodies were found in Dehradun and Rudraprayag, which accounted for 2 per cent (1) each.

With a count of 57 villages, the Maximum number of villages were assessed in Chamoli district. On the other hand, with a count of 2, the least number of villages were assessed in Dehradun.

The following twenty-one blocks in their respective Ganga districts did not have water bodies:

District Name	Block with No Water body
Pauri(Garhwal)	Dwarikhal
Pauri(Garhwal)	Khirsu
Pauri(Garhwal)	Kot
Pauri(Garhwal)	Pauri
Pauri(Garhwal)	Yamkeshwar
Tehri(Garhwal)	Bhilangna
Tehri(Garhwal)	Chamba
Tehri(Garhwal)	Deoprayag

Table 7: Blocks of Bihar with no water bodies

District Name	Block with No Water body
Tehri Garhwal	Jakhnidhar
Tehri Garhwal	Kirtinagar
Tehri Garhwal	Pratapnagar
Tehri Garhwal	Thauldhar
Uttarkashi	Bhatwari
Uttarkashi	Chinyalisaur
Uttarkashi	Dunda
Chamoli	Ghat
Chamoli	Joshimath
Chamoli	Pokhari
Haridwar	Laksar
Rudraprayag	Jakholi
Rudraprayag	Ukhimath

Table 7: Blocks of Uttarakhand with no water bodies

4.1.2 Scorecard: Uttarakhand

4.1.2.1 District-wise scores and descriptors

Below table depicts a tabular representation of the scores acquired by each district of Uttarakhand along with performance descriptor and its rank:

State: Uttarakhand			
Rank	District	Score (300)	Descriptors
1	Rudraprayag	215	Good
2	Chamoli	203.54	Good
3	Dehradun	200	Good
4	Haridwar	183.99	Good

Table 8: District-wise scores and descriptors

4.1.2.2 Graphical representation of District-wise score of Uttarakhand

Scores have been summarized on the basis of all the seven indicators mentioned in scoring methodology, which were considered as the key factors for evaluation of the water bodies. As per the evaluation, Uttarakhand stands with an average score of 200.63 out of 300.

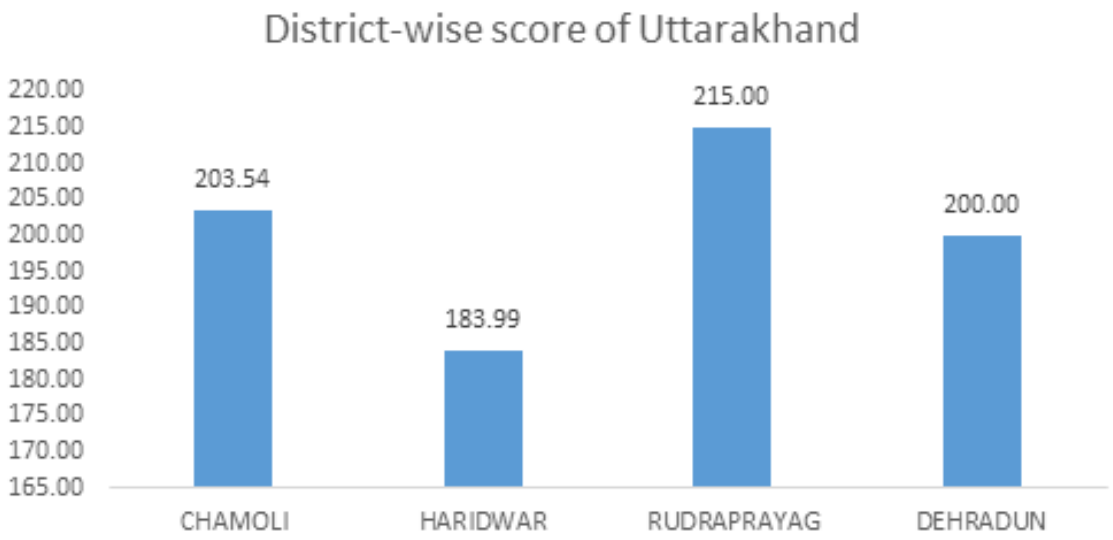


Figure 4.2: District-wise scores of Uttarakhand

The resultant score indicates an overall 'Good' performance by the State. Rudraprayag was found to be the best performing district with a score of 215. However, Haridwar with a score of 183.99, found to be the worst performing district of Uttarakhand.

4.1.2.3 Indicator-wise scores of Uttarakhand

The figure given below represents indicator-wise comparison of the State average and National average scores. Evaluation of scores and grades was done on the basis of seven key indicators mentioned in the graph below:

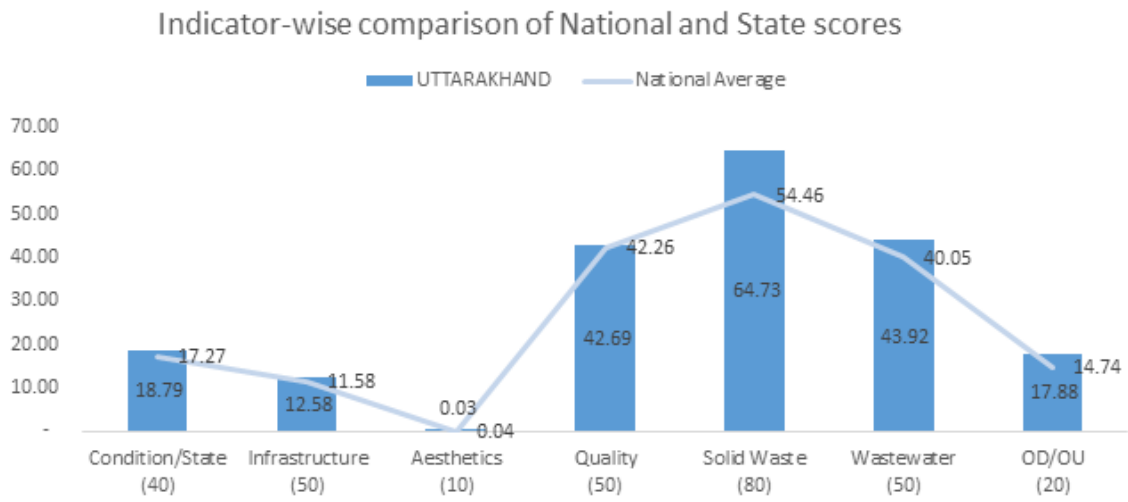


Figure 4.3: Indicator-wise comparison of National and State scores

1. **Condition/state,** which plays a significant role in determining overall health a water body and the reason for its rejuvenation or depletion. Factors affecting the condition of water bodies are types of settlement and septic tanks present near them.
2. **Infrastructure** signifies the physical structure of a water body, which includes the condition of fencing, road connectivity around the water body and outlet channel to ensure drain-out of overflow. This indicator plays a vital role in resolving the issue of water bodies being dried-up.
3. **Aesthetics (Aesthetic enhancement)** includes beautification around the water bodies, which includes benches, bridges, religious architectures/idols, sheds, grass/gardening, etc.
4. **Quality** as an indicator comprise of factors like turbidity status, eutrophication, and formation of foam, which comprehends the severity in terms of quality of water present in a water body.
5. **Solid Waste** includes waste present around/on the surface of water bodies. It checks on factors like availability of the dustbins, flies over the Garbage Vulnerable Points (GVPs) and leachate coming out from it, which might directly contaminate a water body.
6. **Wastewater** includes the status and type of drainage run-off and direct contamination of water body due to it.
7. **OD/OU** indicator indicates the presence of the human faecal matter, animal dung and urination around water body. It acts as a major role behind the growth of algae and plants into the water body.

The line graphs depict indicator-wise National average of the survey and the bar graph represents the indicator wise scores of Uttarakhand.

- Indicators of Uttarakhand namely, Aesthetics and Quality maintains the mean score corresponding to the National score.
- Whereas, in terms of Condition/State, Infrastructure, Solid waste disposal, Wastewater drainages and OD/OU score of Uttarakhand is better than the National score.

4.1.2.4 Performance based descriptors of Uttarakhand

Water bodies found in various districts of Uttarakhand were lying under different descriptors as per their performances. These descriptors are characterized by seven indicators for evaluation of water bodies, which denotes 'Water body Cleanliness Index'.

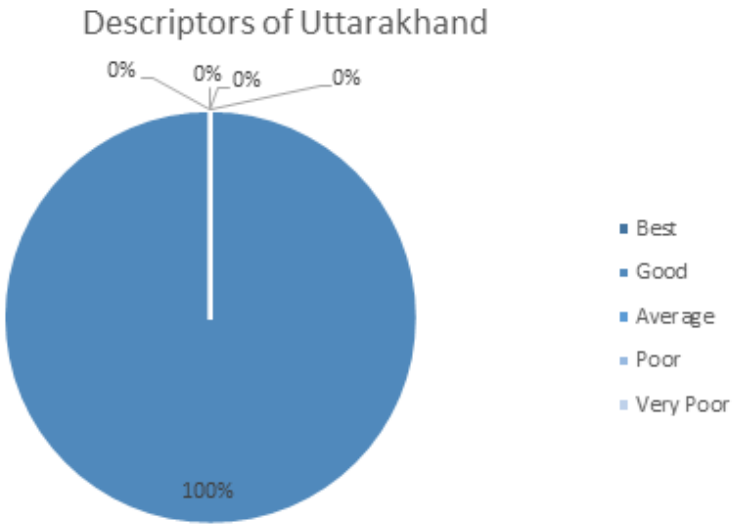


Figure 4.4: Performance based descriptors of Uttarakhand

'Best' and 'Good' indicates that lower level of intervention is required for the water bodies, whereas, 'Poor' and 'Very Poor' signifies that higher level of intervention is needed for rejuvenation and sustainability of the water bodies. In addition, medium level of intervention is required for water bodies lying under 'Average' category.

As per the figure, all 44 water bodies found in Uttarakhand falls under 'Good' descriptor which requires less of revival and more measures of sustainability.

4.1.3 Key findings

The data was thoroughly revised and underwent a rigorous three-layered quality check so that important findings of the study could be highlighted for each state or district.

'Figure 4.5' summarizes all the key findings with respect to the selected 4 Districts of Uttarakhand situated in Ganga Basin. Across these districts, a total of 111 villages have been assessed by QCI. Out of which, a total of 44 water bodies were found in 29 Ganga villages during the survey. The percentage figures highlight that how many water bodies had the presence of below-mentioned parameters out of the total water bodies surveyed. These figures may be attributed to the performance of a water body in the 'Water Body Cleanliness Index'.

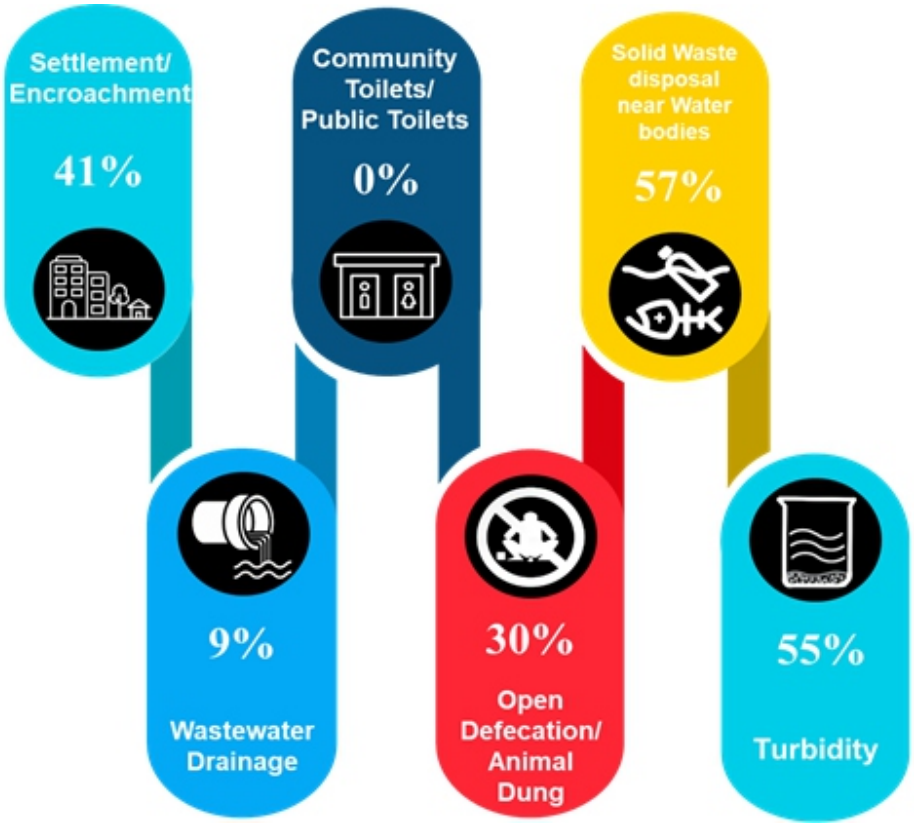


Figure 4.5: Key findings of water bodies found in Uttarakhand

4.1.3.1 Categorization of water bodies (Healthy/ Water hyacinth/Eutrophied/ Dried up)

Categorization constitutes the total number of water bodies found in each state based on their condition. This helps in determining the 'Level of Intervention' required. As per the data collected from on-field assessment, water bodies are divided into 4 categories.

Figure mentioned below is with respect to the categorization of 44 water bodies assessed during the survey:

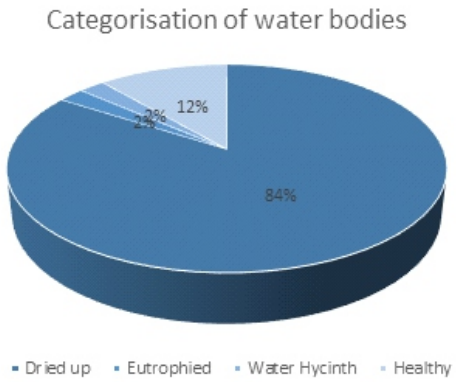


Figure 4.6: Categorization of water bodies

In Uttarakhand, only 12 per cent of the water bodies were found to be healthy and only 2 per cent had Water hyacinth present in them. The study also found that, these water bodies had socio-economic benefits attached with them. For example: Domestic usage, Irrigation purposes, drinking water for cattle and pisciculture.

However, 84 per cent of the total water bodies were Dried-up. These water bodies were converted into dumping sites by the villagers according to the photographs received on assessment portal. Also, 2 per cent of the water bodies were found to be Eutrophied i.e. water bodies having algal blooms/layers and low oxygen saturation levels. It was found that villagers living nearby these water bodies, were not able to use water for any domestic or commercial benefits. Only Ground-water recharge could be done as per the key informants.

The results based on these findings indicated towards a dire need to implement rejuvenation plans to sustain the existing water bodies present in the Ganga basin.

4.1.3.2 Settlements under Catchment area

Catchment area of a water body plays a crucial role in determination of its overall health. Either it becomes a reason for its replenishment through sources like Storm water drainages or it can become a cause for its depletion due to contamination from Wastewater drainages, Industrial effluents and Solid waste disposal, which constitutes as factors of non-point source pollution. Hence, dense settlements in the catchment area can alter the status of the water bodies.

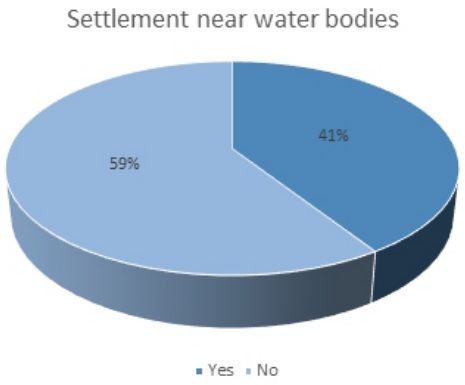


Figure 4.7: Settlement near water bodies

a. Figure mentioned below is with respect to the 'Settlements (within 250m)' found out of 44 water bodies assessed during the survey:

Settlements were found near 41 per cent of the total water bodies which can become a major reason for its contamination. Moreover, cases of illegal possession of land around the water bodies were found according to the citizen feedbacks.

b. Figure mentioned below is with respect to the percentage distribution of Settlement found near 18 water bodies across 3 districts:

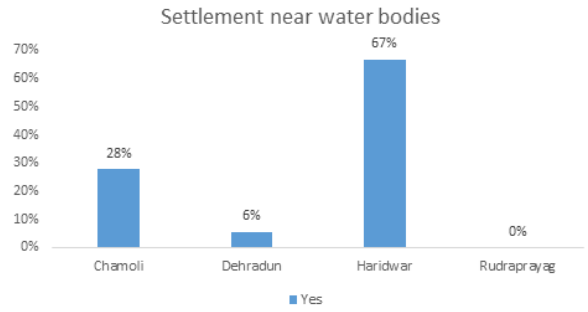


Figure 4.8: Settlement near water bodies (District-wise)

- Highest percentage of settlements was found near water bodies present in Haridwar district with 67 per cent.
- Lowest percentage of Settlements was found near water bodies present in Dehradun with 6 per cent.

Note : No settlement was found near water bodies identified in Rudraprayag.

c. The figure mentioned below is with respect to the 'Percentage distribution of

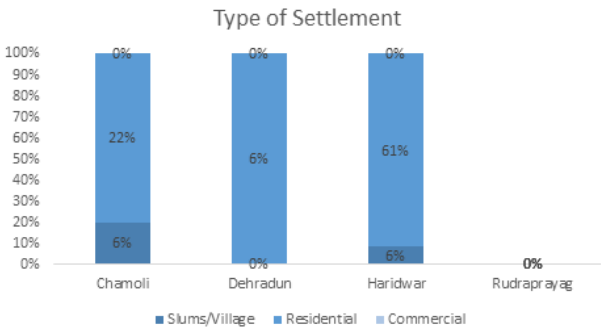


Figure 4.9: Type of Settlement (District-wise)

Type of Settlements' found near 18 water bodies across 3 districts:

- 6 per cent of Slum/Village was found in Districts: Chamoli and Haridwar each.
- Highest percentage of Residential settlements was found in Haridwar with 61 per cent. Whereas, lowest was found in Dehradun with 6 per cent.

About, 37 per cent of the water bodies having settlements nearby, were found as either highly eutrophied or dried up. Hence, health of the water bodies present in these villages depended upon factors like Washing, Bathing, Leachate, Septic tank and its Drainage run-off.

Note: No settlement was found near water bodies identified in Rudraprayag. Also, no Commercial settlement was found nearby water bodies assessed in Uttarakhand.

4.1.3.3 Drainage

A part of this survey focused on 'Wastewater' drainages found near the water bodies and their impacts on the Catchment area. These drainages had their outlets connected from nearby households, space available for washing/bathing, construction sites, small-scale factories and agricultural fields. Wastewater drainage is one of the major causes of contamination, which disturbs the ecosystem of a water body. On the other hand, Rain and Storm water drainages were found to be natural sources for its replenishment.

a. Figure mentioned below is with respect to the 'Wastewater drainage' found out of 44 water bodies assessed during the survey:

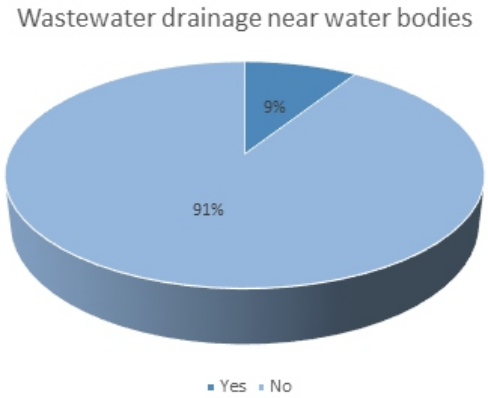


Figure 4.10: Wastewater drainage near water bodies

About 9 per cent of the total water bodies found in Uttarakhand were found having Wastewater drainage on its edge/nearby or connected in a way that it inflicted them primarily. Drainage run-off directly into the water bodies turned out to be one of the major factors for Algal blooms and Low oxygen saturation levels present in it.

According to the survey, wastewater drainages could only be found in 4 water bodies identified in Haridwar district. These drainages found to be directly contaminating the water bodies.

This study states that flow of Storm-water drainage directly into the water bodies replenished them. On the other hand, flow of wastewater drainage directly into water bodies is harmful for its health. Moreover, it was observed that Secondary treatment plant or Filtration mechanism were not found near water bodies.

As per the assessment, wastewater drainages found near water bodies identified in Uttarakhand, did not have any screens/mesh/grill/bars at its openings. Hence, paving the way for accumulation of solid waste and excessive nutrients into the water bodies.

4.1.3.4 Correlation

Correlation of dried-up water bodies with road connectivity came out as 0.2737. It can be interpreted that construction of road is one of the causes of water bodies ending up dried.

4.1.3.5 Solid waste found around/on the surface of water bodies

Absence of dustbins near water bodies resulted in increased accumulation of wet and dry waste that subsequently led to its contamination. Additionally, leachate formed due to accumulation of dry and wet waste causes foul smell and foaming, which directly affected heath of the water bodies.

a. Figure mentioned below is with respect to the Solid Waste present around/on the surface out of 44 water bodies assessed during the survey:

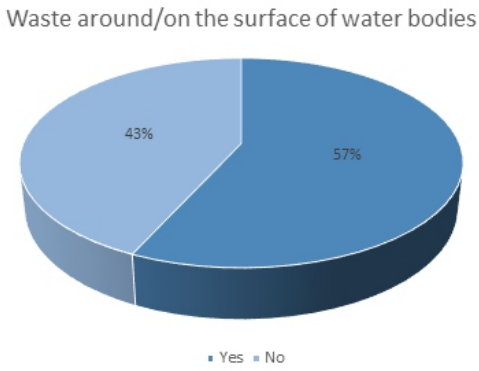


Figure 4.11: Waste around/on the surface of water bodies

Out of 44, 25 water bodies had solid waste present around/on its surface. Furthermore, it was found that, there were no methods of Fine mechanisms or Anti-littering signage near public water bodies to discourage such unhealthy activities.

Hence, it is observed that awareness campaigns were primarily needed to be conducted to avoid such uninhabitable conditions.

b) Figure mentioned below is with respect to the percentage distribution of Solid waste found around/on the surface of 25 water bodies across 2 districts:

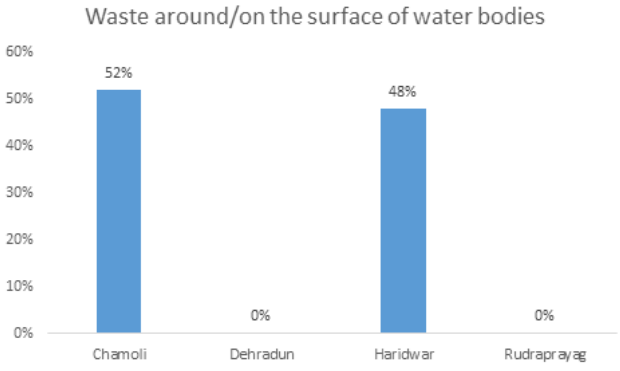


Figure 4.12: Waste around/on the surface of water bodies (District-wise)

Solid waste was found around/on the surface of 25 water bodies. District-wise bifurcation of the same is mentioned in the above figure.

- Chamoli was found with highest percentage of solid waste around/on the surface of water bodies with 52 per cent.
- Haridwar was marked with lowest percentage of solid waste found around/on the surface of water bodies with 48 per cent.

Note : No kind of waste was found around/on the surface of water bodies identified in Dehradun and Rudraprayag.

4.1.3.6 Community toilet/Public toilet management near water bodies

a. Figure mentioned below is with respect to the 'Community toilet/Public toilet' found out of 44 water bodies assessed during the survey:

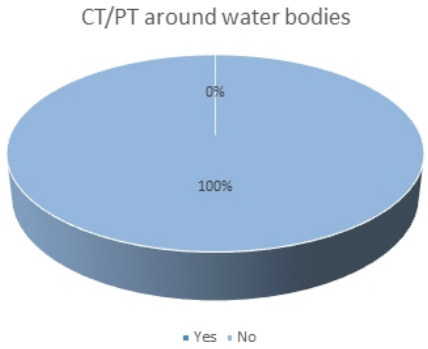


Figure 4.13: CT/PT around water bodies

No Community/Public toilet was found near the water bodies, which were identified in Uttarakhand.

The toilets should be made at a distance of 50 meters at least, so that it does not lead to open defecation and open urination near water bodies. Furthermore, septic tank waste can be prevented from entering the water bodies and safe disposal could be ensured.

Hence, non-availability of the same leads to Open Defecation and Open Urination nearby water bodies.

4.1.3.7 Open Defecation (Animal dung/Human faecal matter) found

a. Figure mentioned below is with respect to the 'Open Defecation' found out of 44 water bodies assessed during the survey:

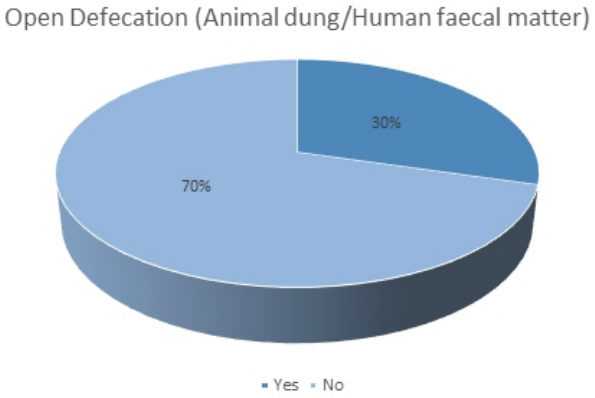


Figure 4.14: Open Defecation (Animal dung/Human faecal matter)

Open Defecation was found around 30 per cent of the total water bodies that were found in Uttarakhand. Rest of the water bodies did not have any sign of Animal dung or Human faecal matter around them.

During such practices, excessive nutrients which constitutes a major proportion of Nitrogen and Phosphorus, enters the water body through Animal dung and Human feces. This turns out to be a reason for excessive plants and algal growth in water bodies. Such conditions can lead to sickness and poor health in humans.

b. Figure mentioned below is with respect to the percentage distribution of Open Defecation' found near 13 water bodies across 2 districts:

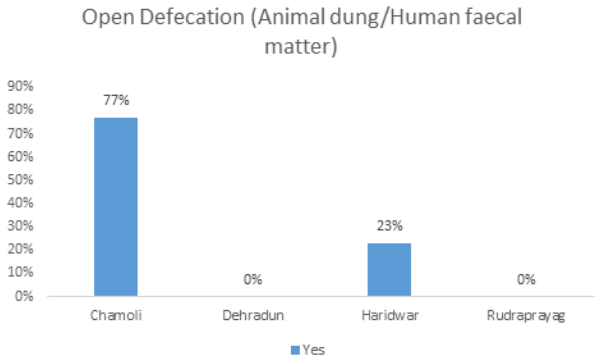


Figure 4.15: Open Defecation: Animal dung/Human faecal matter (District-wise)

4.1.3.8 Turbidity assessment (Water quality)

Turbidity test could be undertaken for 20% (Healthy + Water Hyacinth + Eutrophication) of the total water bodies found in Uttarakhand.

Figure mentioned below is with respect to 'Turbidity (Beaker test)' of water present in 9 water bodies during assessment:

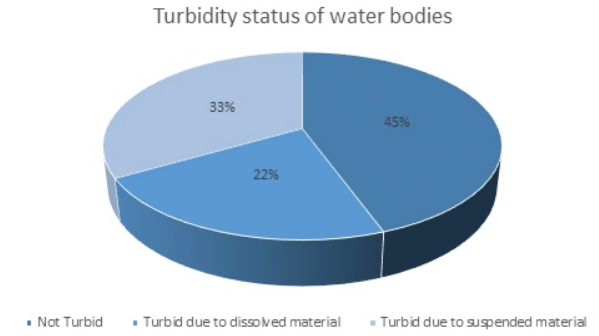


Figure 4.16: Turbidity status of water bodies

Non-point sources of pollution like Agricultural fields, Industry/factory and Construction sites discharging excessive nutrients/minerals, harmful chemicals/effluents and Silt respectively, were found to be directly affecting the water quality. On the other hand, local habitat activities such as Washing, Drain connect, Open Defecation played a direct role in worsening the water body's health.

About 45 per cent of the total water bodies were found to be 'Not Turbid'. This implied that the quality of water is good whereas, 22 per cent of the water bodies were found to be 'Turbid due to dissolved material'. It means, mud/silt is present is present in huge amount.

Only 33 per cent of the water bodies were found to be 'Turbid due to suspended material', which defines the presence of heavy siltation, small pebbles and other solid waste. However, a scientific exception stating presence of temporary siltation and small stones/pebbles was not considered damaging the health of water bodies.

These factors lead to the Eutrophication (formation of layers of Algae), which by time lowers the oxygen saturation levels, blocks sunlight to reach water body's bed and ultimately damages its eco-system. Accumulation of solid waste on the surface of water bodies and its Bed majorly disrupts daily utility benefits, which the local inhabitants enjoy. Some of the major disruptive activities includes pious activities, Idol immersion, disposing Clothes, Leather, Plastics, Tin, etc.

4.1.3.9 Additional indicators

Figure depicted below is with respect to some other indicators of 44 water bodies that were assessed during the survey:

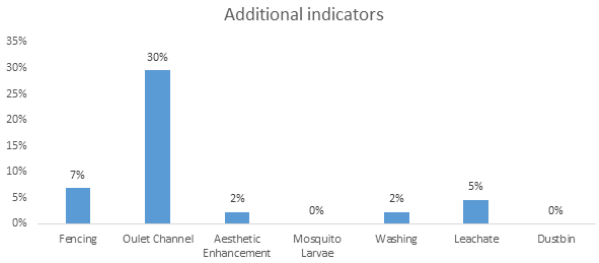


Figure 4.17: Additional indicators assessed during the survey

Fencing can be metal, Cemented, Barbed wire, Wooden, Vinyl or made of Plant (Bio-fencing) to restrict unwanted entry of cattle near water bodies. On-ground assessment indicates that only 7 per cent of the total water bodies had fencing on its periphery. Bio-fencing plays a major role in maintaining health of a water body and works as a shield against non-point sources of pollution. In addition, small trees on the edges of a water body holds the Pal (Boundary) in order to maintain the water body's depth.

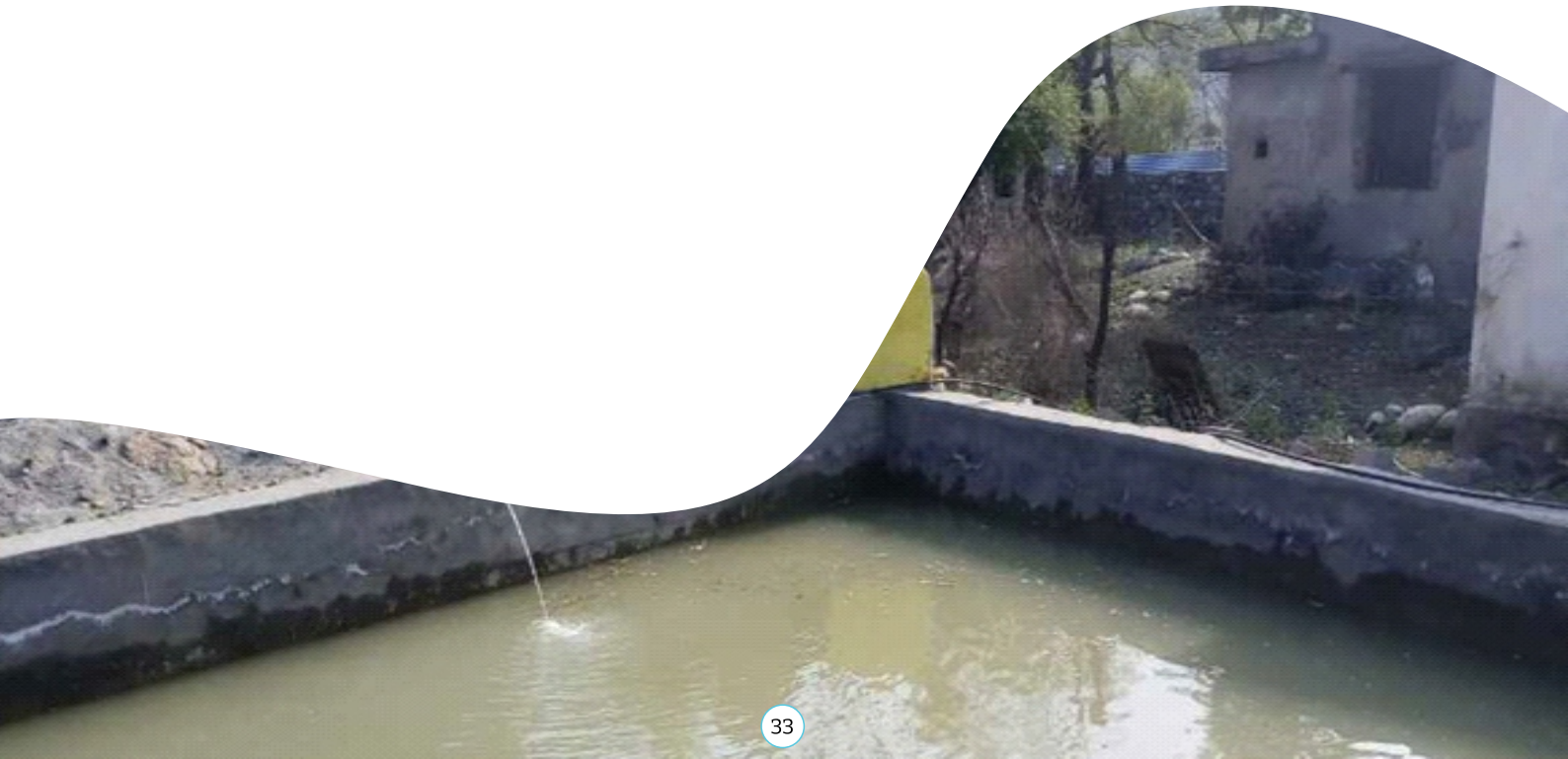
30 per cent of the total water bodies had **Outlet channels** to deal with the overflow and flood like conditions. Cemented and Mud-pitched type outlet channels were found during the survey, which is a good sign for any water body.

Villagers find it inconvenient to get utility benefits from water bodies especially during high temperatures in absence of sheds, as per the survey. It was observed that only 2 per cent of the total water bodies have **Aesthetic enhancement**/beautification around them, which might include benches, bridges, fencing, sheds and grass/gardening.

Mosquito Larvae was not found water bodies assessed in Uttarakhand. It is detected through Turbidity tests undertaken by assessors in a transparent beaker or transparent disposable container. Villagers do not consume this water due to its high contamination level/load of pollutants as well as the fact that the area is prone to diseases like Malaria, Dengue and Chikungunya.

'Washing' (under 50m) as an activity was observed around/on the edges of 2 per cent of the total water bodies. This contaminated the water bodies directly as per direct observation. 'Grey water' is claimed to be harmful for water bodies as it enters without any secondary treatment or filtration process. In a similar manner, 5 per cent of the total water bodies were found to be contaminated by direct flow of **leachate.**

No **dustbins** were present nearby the water bodies identified in Uttarakhand for Solid Waste Management (SWM). Absence of dustbins leads to accumulation of waste around and on the surface of water bodies, which is harmful for its health.



4.1.4 District Overview: Report card and Scorecard

4.1.4.1 DISTRICT REPORT: Rudraprayag

Configuration

The following bar graph represents the count of water bodies along with the number of villages assessed in a particular block.

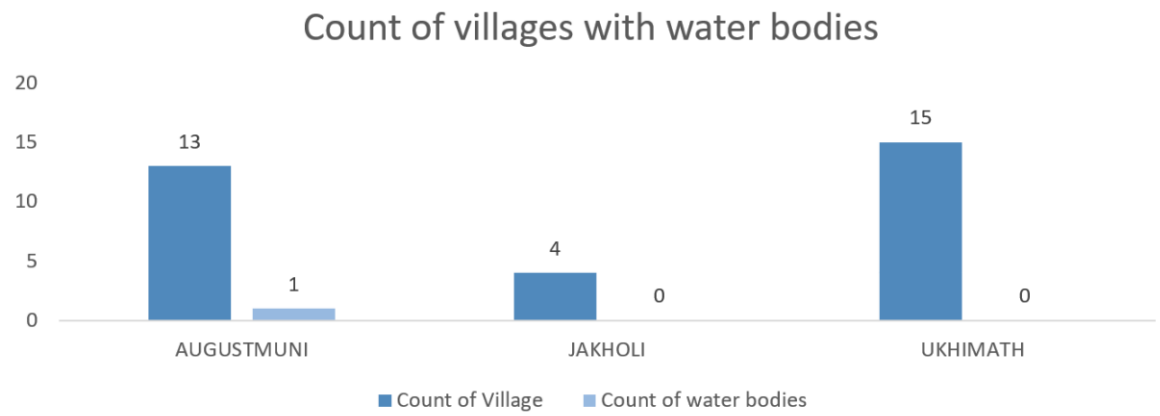


Figure 4.18: Count of villages in Rudraprayag with water bodies

Three blocks in Rudraprayag district were within Ganga basin. Only 1 water body was identified during the survey of 32 villages in Rudraprayag.

- 13 villages were assessed in Augustmuni block where only 1 water body was found.
- 10 water bodies were found in Simri block despite having the maximum village count as 22.
- 4 and 15 villages were assessed in Jakholi and Ukhimathi block but no water body was found, hence no parameters could be assessed for them.

Categorization of the water bodies

Water bodies have been categorized in four groups based on their status: Healthy, Water-Hyacinth, Eutrophication, and Dried-up.

A water body is categorized as **Healthy** if the general appearance is clean and traces/layer of algae is not present in it.

Presence of **Water-hyacinth** is safe for the water bodies until it is present in controlled amount. This plant requires threshing to prevent blockage, so that sunlight could reach the water body bed and it does not become a home for disease-carrying mosquitoes.

A **dried-up** water body indicates that the catchment yield and inlet systems for its replenishment are not active or blocked.

Eutrophication is caused due to presence of excessive nutrients like Phosphorous and Sulphur in water bodies, which can enter through non-point sources of pollution. This leads to increased amount of plant and algal growth, which damages the aquatic life and ecosystem of the water bodies. Water bodies under such condition are on the verge of depletion and requires higher level of intervention.

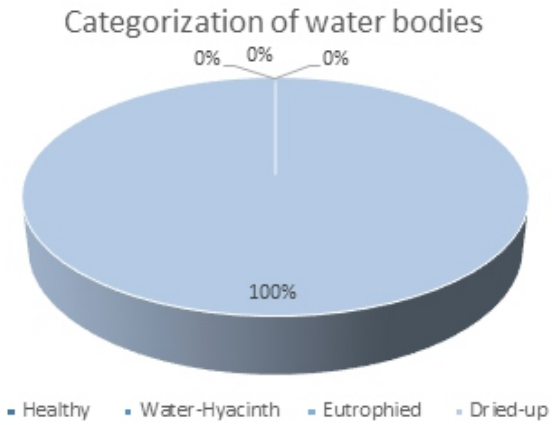


Figure 4.19: Categorization of water bodies in Rudraprayag

The study found that the only water body was dried-up.

Turbidity

Turbidity test was not conducted in the Rudraprayag district as the only water body found in the Ganga basin was dried up.

Settlement near water bodies

Type of settlement plays a major role in determining the catchment yield of a water body. Difference in type and load of pollutants was observed through a Slum area and a Residential area. For example: Animal dung, chemical/fertilizers from Slum/village area becomes the cause of pollution in water bodies and on the other hand Solid waste, Silt from under-construction sites in Residential areas are the causes of contamination. However, in exceptional cases the load of pollutants entering into a water body may not vary as per our Project Expert.

No settlement was found near the water body within 200-250 meters of its radius in Augustmuni block.

Wastewater drainage and Solid waste

Wastewater drainages present in residential area settlements may cause accumulation of solid waste near and on the surface of water bodies. Screens/mesh/bars restricts solid waste from entering into the water body. However, pollutants which enters the water bodies along with the solid waste and wastewater drainages deteriorate the quality of water present in it. Excessive nutrients like Phosphorus and Sulfur coming from these non-point sources of pollution leads to eutrophication, which damages the overall health of the water bodies.

Pie-chart, Figure 4.20 represents Wastewater drainage present near water bodies assessed in Rudraprayag where the water body found was not contaminated through wastewater drainage.

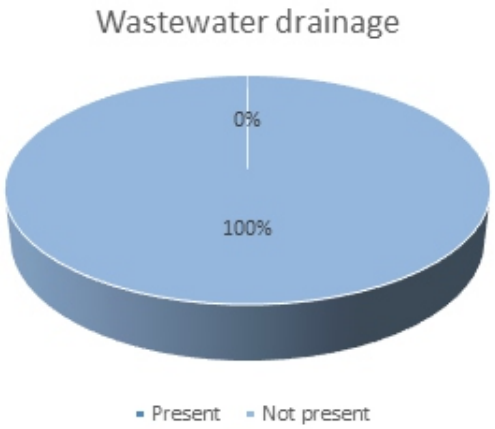


Figure 4.20: Wastewater drainage in and around water bodies in Rudraprayag

No solid waste was found in/around the water bodies found in Rudraprayag.

DISTRICT SCORECARD: RUDRAPRAYAG

Block-wise scores and Descriptors

Below is a tabular representation of the score of Rudraprayag block along with its grade:

Rank	Block	Score	Descriptors
1	Augustmuni	215.0	Good

Table 9: Ranking of Blocks in Rudraprayag based on scores

Scores have been summarized on the basis of all the seven indicators which were considered as the key factors for evaluation of the water bodies out of a total marks of 300.

On the basis of performance, it was found that the only water body present in Rudraprayag stands with an average score of 215 out of 300. The resultant score indicates a 'Good' performance by Rudraprayag district.

Indicator-wise scores of Rudraprayag

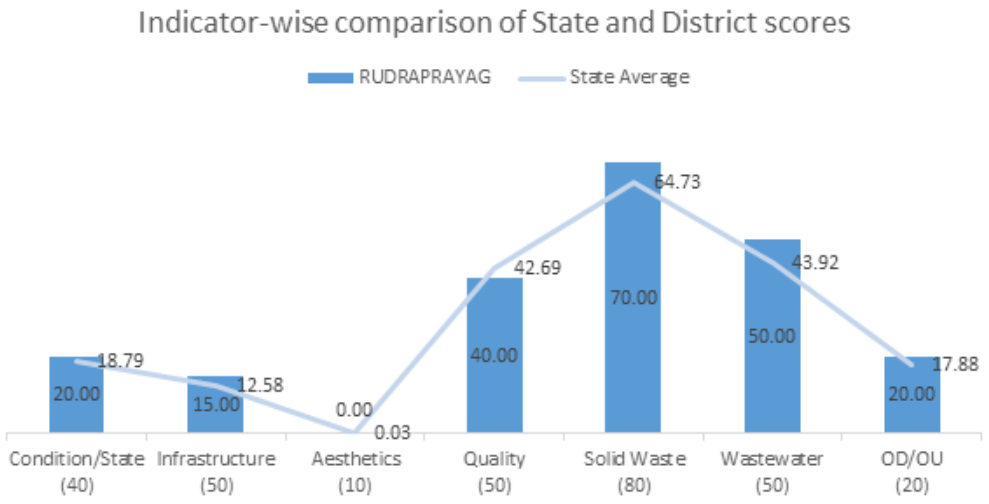


Figure 4.21: Indicator-wise scores of Rudraprayag

Above bar graph represents the overall score of Rudraprayag district. Evaluation of scores and grades was done on the basis of seven key indicators mentioned below:

1. Functionality, which play a significant role in determining overall health a water body and the reason for its rejuvenation or depletion. Factors affecting the functionality of water bodies are types of settlement and septic tanks present near them.
2. Infrastructure signifies the physical structure of a water body, which includes the condition of fencing, road connectivity around the water body and outlet channel to ensure drain-out of overflow. This indicator plays a vital role in resolving the issue of water bodies being dried-up.
3. Aesthetics (Aesthetic enhancement) includes beautification around the water bodies, which includes benches, religious architectures, sheds, grass/gardening, etc.
4. Quality as an indicator comprise of factors like turbidity status, eutrophication, and formation of foam, which comprehends

the severity in terms of quality of water present in a water body.

5. Solid Waste includes waste present around/on the surface of water bodies. It checks on factors like availability of the dustbins, flies over the Garbage Vulnerable Points (GVPs) and leachate coming out from it, which might directly contaminate a water body.
6. Wastewater includes the status and type of drainage run-off and direct contamination of water body due to it.
7. OD/OU indicator indicates the presence of the human faecal matter, animal dung and urination around water body. It acts as a major role behind the growth of algae and plants into the water body.

The line graphs depicts indicator-wise State average of the survey and the bar graph represents the indicator wise scores of Rudraprayag district.

- In terms of Aesthetics, Rudraprayag maintains the mean score corresponding to the State score.
- Whereas, in terms of Condition/State, Infrastructure, Solid waste disposal, Wastewater drainage and OD/OU, score of Rudraprayag is better than the State score.
- However, Rudraprayag performed poorer than the State in terms of Quality.

Performance based descriptors of Rudraprayag

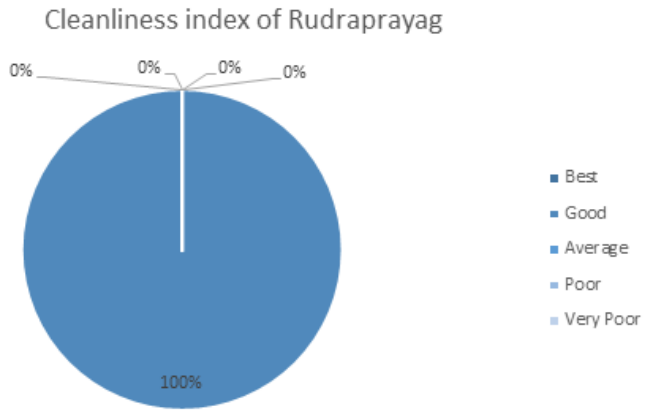


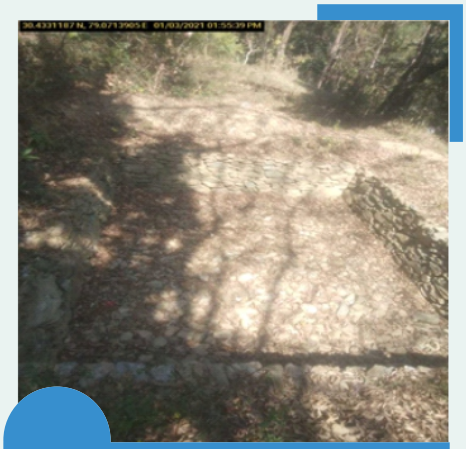
Figure 4.22: Cleanliness index of Rudraprayag

Water body found in Augustmuni block of Rudraprayag lies under 'Good' descriptor as per its performances. Descriptors are characterized by different water body indicators, which denotes water body Cleanliness Index.

'Best' and 'Good' indicates that lower level of intervention is required, whereas, 'Poor' and 'Very Poor' signifies that higher level of intervention is needed for rejuvenation and sustainability of a water body. Furthermore, medium level of intervention is required for water bodies lying under 'Average' category.

As per the figure, 100 per cent of the water bodies fall under 'Good' descriptor but requires revival and need to be sustained as the only water body found was dried-up.

Images of water bodies in RUDRAPRAYAG



Dried up
UK_CHANDRAPURI_42263_012111_W1

No encroachment
UK_CHANDRAPURI_42263_012111_W1

No fencing available
UK_CHANDRAPURI_42263_012111_W1

No Aesthetic enhancement
UK_CHANDRAPURI_42263_012111_W1

No waste inside
UK_CHANDRAPURI_42263_012111_W1

No waste around
UK_CHANDRAPURI_42263_012111_W1

No open defecation
UK_CHANDRAPURI_42263_012111_W1

4.1.4.2 DISTRICT REPORT: CHAMOLI

Configuration

The following bar graph represents the count of water bodies along with the number of villages assessed in a particular block.

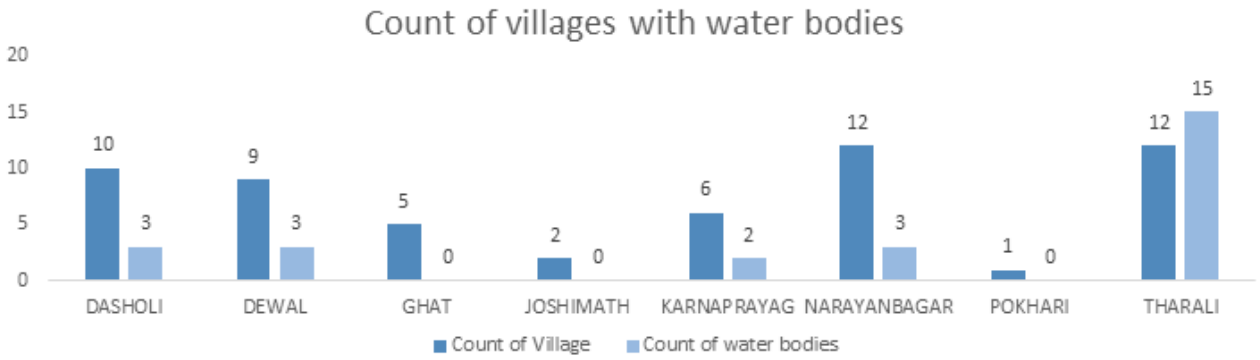


Figure 4.23: Count of villages in Chamoli with water bodies

Eight blocks of Chamoli district were found to have water bodies within Ganga basin. 26 water bodies were identified during the survey of 57 villages in Chamoli.

- 12 villages were assessed in Narayanbagar and Tharali each. During the survey, 3 and 15 water bodies were found respectively. Tharali recored the highest water bodies in the Chamoli district.
- Karnaprayag recorded the lowest water bodies in the district with the count of just 2.

No water bodies could be found in Ghat, Joshimath, and Pokhari block; hence, no parameters could be assessed for them.

Categorization of the water bodies

A water body is categorized as **Healthy** if the general appearance is clean and traces/layer of algae is not present in it.

Presence of **Water-hyacinth** is safe for the water bodies until it is present in controlled amount. This plant requires threshing to prevent blockage, so that sunlight could reach the water body bed and it does not become a home for disease-carrying mosquitoes.

A **dried-up** water body indicates that the catchment yield and inlet systems for its replenishment are not active or blocked.

Eutrophication is caused due to presence of excessive nutrients like Phosphorous and Sulphur in water bodies, which can enter through non-point sources of pollution. This leads to increased amount of plant and algal growth, which damages the aquatic life and ecosystem of the water bodies. Water bodies under such condition are on the verge of depletion and requires higher level of intervention.

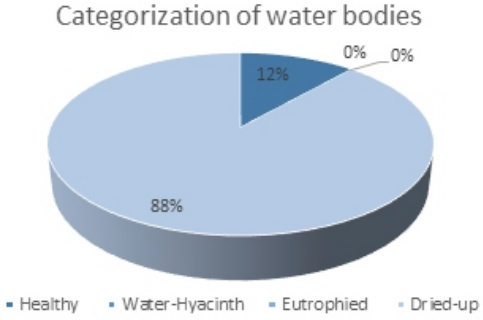


Figure 4.24: Categorization of water bodies in Chamoli

The study found that 88 per cent of the total water bodies fall under Dried-up category and only 12 per cent in the Healthy category. Proportion of water bodies lying under Healthy category was found to be comparatively low, which is a sign of poor catchment yield and lack of awareness among the locals.

Turbidity

Turbidity test was undertaken for 3 water bodies of Chamoli district, as per the availability of water.

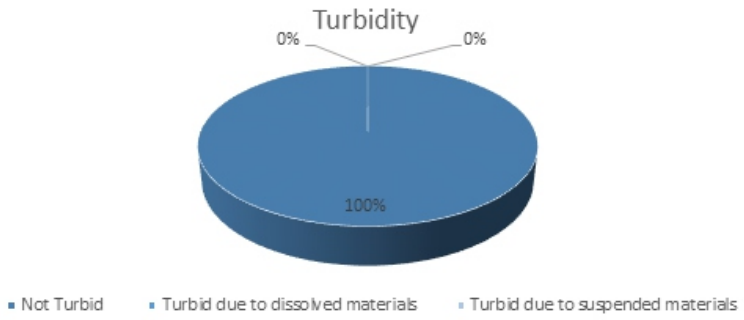


Figure 4.25: Turbidity in water bodies of Chamoli

As per Figure 4.25, 100 per cent of the water bodies came out to be 'Not Turbid' that denotes clear and transparent water which is good for usage and health of habitat situated nearby.

Settlement near water bodies

depicts block-wise 'Percentage distribution of Settlement' found in Chamoli district. 100% accountability has been captured under 2 blocks with a total count of 5 Water bodies, having settlement present within 200-250 meters of its radius. 40 per cent in Karnapyayag and 60 per cent in Tharali.

No settlement was available near water bodies, which were found in Blocks: Dasholi, Dewal, and Narayanbagar.

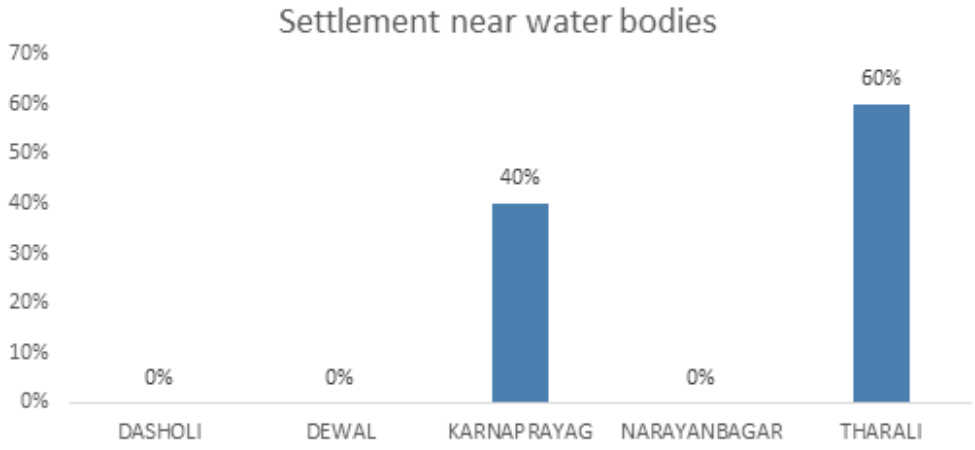


Figure 4.26: Settlement near water bodies in Chamoli

Figure 4.27 configures two types of settlement. 20 per cent of the water bodies in the two blocks where water bodies were found, have Slums/village type of settlement, whereas, as much as 80 per cent of the water bodies were surrounded by Residential households.

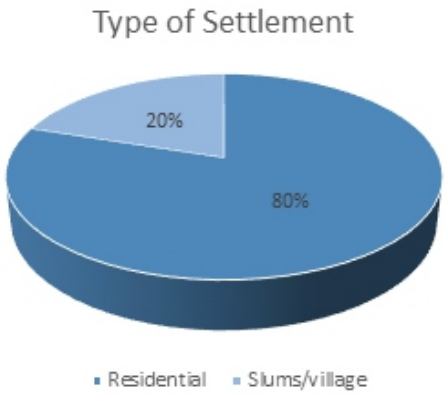


Figure 4.27: Type of Settlement around water bodies in Chamoli

Type of settlement plays a major role in determining the catchment yield of a water body. Difference in type and load of pollutants was observed through a Slum area and a Residential area. For example: Animal dung, chemical/fertilizers from Slum/village area becomes the cause of pollution in water bodies and on the other hand Solid waste, Silt from under-construction sites in Residential areas are the causes of contamination. However, in exceptional cases the load of pollutants entering into a water body may not vary as per our Project Expert.

Wastewater drainage and Solid waste

As per the Pie-chart, Figure 4.28 there is no wastewater drainage present near water bodies assessed in Chamoli.

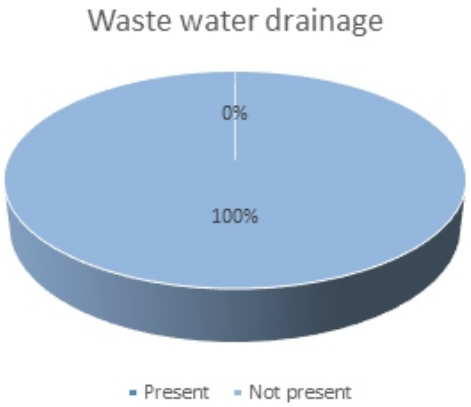


Figure 4.28: Wastewater drainage in and around water bodies in Chamoli

As per Figure 4.28, it was observed that,

- Tharali accounts for the highest total as 59 per cent of the water bodies had solid waste present in/around them.
- In Karnaprayag and Narayanbagar, 18 per cent and 12 per cent of the water bodies respectively have solid wastes in and around them.
- In Dasholi and Dewal, both 6 per cent of water bodies have solid waste present in/around them.

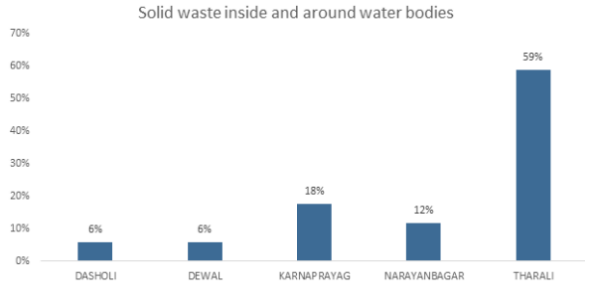


Figure 4.29: Solid waste inside and around water body in Chamoli

Wastewater drainages present in residential area settlements may cause accumulation of solid waste near and on the surface of water bodies. Screens/mesh/bars restricts solid waste from entering into the water body. However, pollutants which enters the water bodies along with the solid waste and wastewater drainages deteriorate the quality of water present in it. Excessive nutrients like Phosphorus and Sulfur coming from these non-point sources of pollution leads to eutrophication, which damages the overall health of the water bodies.

DISTRICT SCORECARD: CHAMOLI

Block-wise scores and Descriptors

Below is a tabular representation of the scores backed by each block of Chamoli along with its grade and rank.

Rank	Block	Score	Descriptors
1	Dasholi	215.7	Good
2	Tharali	209.8	Good
3	Narayanbagar	205.0	Good
4	Dewal	200.6	Good
5	Karnaprayag	186.7	Good

Table 10: Ranking of Blocks in Chamoli based on scores

Graphical representation of block-wise scores of Chamoli

Scores have been summarized on the basis of all the seven indicators which were considered as the key factors for evaluation of the water bodies out of a total marks of 300.

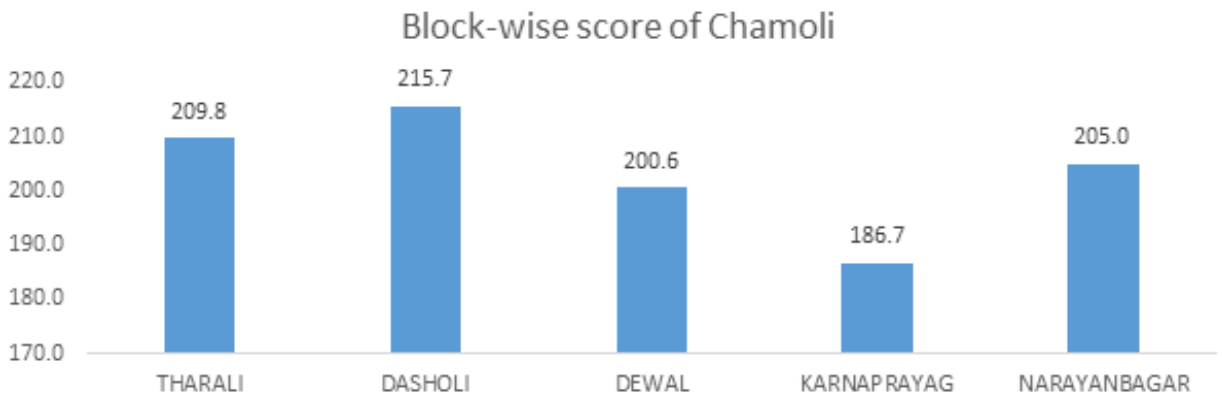


Figure 4.30: Block-wise score of Chamoli

On the basis of performance, it was found that water bodies present in various blocks of Chamoli stands with an average score of 203.44 out of 300. The resultant score indicates a 'Good' performance by Chamoli district.

- Dasholi tops the chart among other blocks, by obtaining an average score of 215.7 out of 300.
- Lowest score has been attained by Karnaprayag as 186.7 among the eight blocks.

Indicator-wise scores of Chamoli

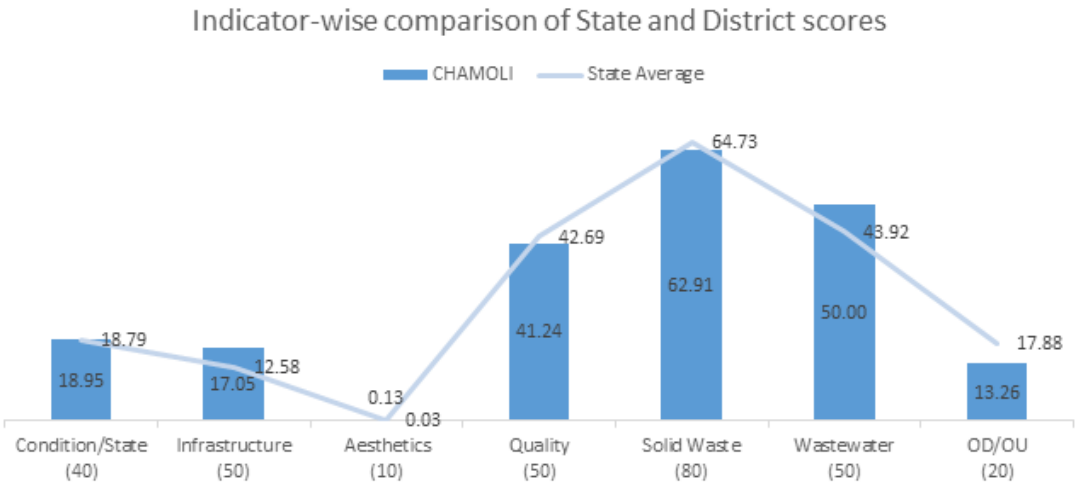


Figure 4.31: Indicator-wise scores of Chamoli

Above bar graph represents the overall score of Chamoli district. Evaluation of scores and grades was done on the basis of seven key indicators mentioned below:

1. **Functionality,** which play a significant role in determining overall health a water body and the reason for its rejuvenation or depletion. Factors affecting the functionality of water bodies are types of settlement and septic tanks present near them.
2. **Infrastructure** signifies the physical structure of a water body, which includes the condition of fencing, road connectivity around the water body and outlet channel to ensure drain-out of overflow. This indicator plays a vital role in resolving the issue of water bodies being dried-up.
3. **Aesthetics (Aesthetic enhancement)** includes beautification around the water bodies, which includes benches, religious architectures, sheds, grass/gardening, etc.
4. **Quality** as an indicator comprise of factors like turbidity status, eutrophication, and formation of foam, which comprehends the severity in terms of quality of water present in a water body.
5. **Solid Waste** includes waste present around/on the surface of water bodies. It checks on factors like availability of the dustbins, flies over the Garbage Vulnerable Points (GVPs) and leachate coming out from it, which might directly contaminate a water body.
6. **Wastewater** includes the status and type of drainage run-off and direct contamination of water body due to it.
7. **OD/OU** indicator indicates the presence of the human faecal matter, animal dung and urination around water body. It acts as a major role behind the growth of algae and plants into the water body.

The line graphs depicts indicator-wise State average of the survey and the bar graph represents the indicator wise scores of Chamoli district.

- In terms of Condition, Aesthetics, and Quality, Chamoli maintains the mean score corresponding to the State score.
- Whereas, in terms of Infrastructure and wastewater, score of Chamoli is better than the State score.
- However, Chamoli performed poorer than the State in terms of OD/OU and Solid waste.

Performance based descriptors of Chamoli

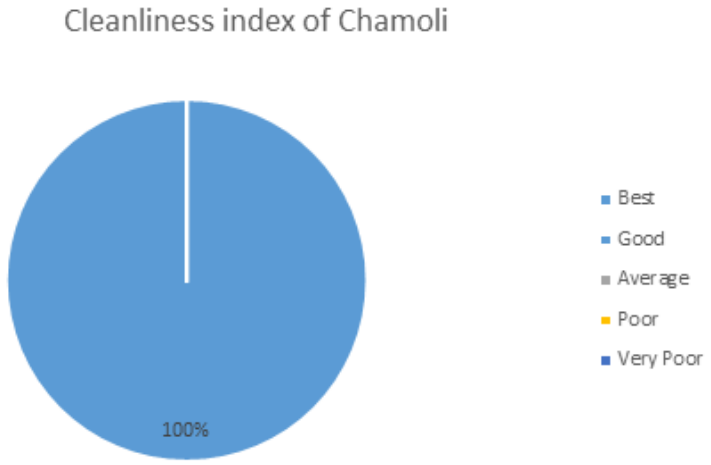


Figure 4.32: Cleanliness index of Chamoli

Water bodies found in various blocks of Chamoli were lying under different descriptors as per their performances. These descriptors are characterized by different water body indicators, which denotes water body Cleanliness Index.

'Best' and 'Good' indicates that lower level of intervention is required, whereas, 'Poor' and 'Very Poor' signifies that higher level of intervention is needed for rejuvenation and sustainability of a water body. Furthermore, medium level of intervention is required for water bodies lying under 'Average' category.

As per the figure, 100 per cent of the water bodies fall under 'Good' which requires less of revival and more of sustainability.

Images of water bodies in CHAMOLI

Healthy
UK_KALESHWAR_*41362_011311_W1

Dried up
UK_LODA_41738_011521_W1

Encroachment
UK_KALESHWAR_*41362_011311

Not turbid
UK_KALESHWAR_*41362_011311

Waste inside
UK_UNI LAGA KOTHI_41765_011181_W1

Waste around
UK_KALESHWAR_*41362_011311

Open defecation
UK_KHAINURI_40956_011091_W1

4.1.4.3 DISTRICT REPORT: DEHRADUN

Configuration

The following bar graph represents the count of water bodies along with the number of villages assessed in a particular block.

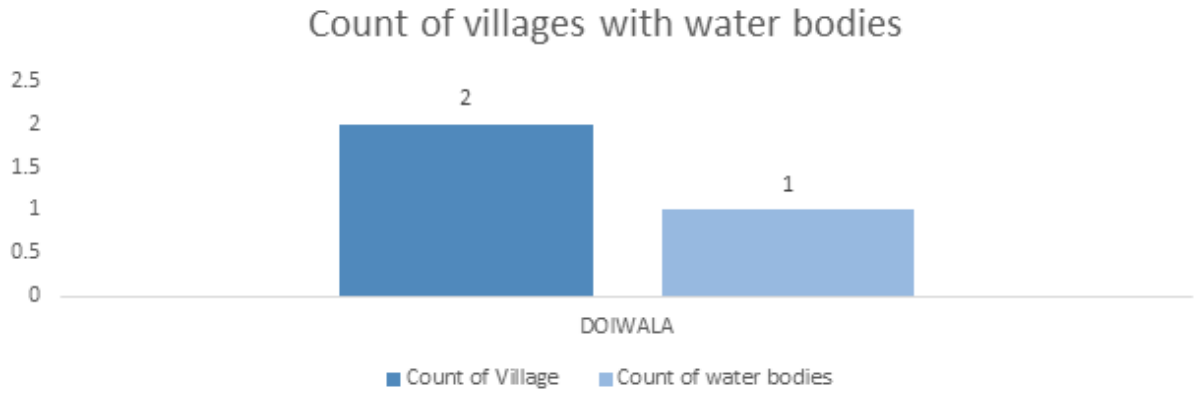


Figure 4.33: Count of villages in Dehradun with water bodies

Only one block of Dehradun district falls under the Ganga basin- Doiwala. Doiwala had 2 villages in which only one water body was found.

Categorization of the water bodies

Water bodies have been categorized in four groups based on their status: Healthy, Water-Hyacinth, Eutrophication, and Dried-up.

A water body is categorized as **Healthy** if the general appearance is clean and traces/layer of algae is not present in it.

Presence of **Water-hyacinth** is safe for the water bodies until it is present in controlled amount. This plant requires threshing to prevent blockage, so that sunlight could reach the water body bed and it does not become a home for disease-carrying mosquitoes.

A **dried-up** water body indicates that the catchment yield and inlet systems for its replenishment are not active or blocked.

Eutrophication is caused due to presence of excessive nutrients like Phosphorous and Sulphur in water bodies, which can enter through non-point sources of pollution. This leads to increased amount of plant and algal growth, which damages the aquatic life and ecosystem of the water bodies. Water bodies under such condition are on the verge of depletion and requires higher level of intervention.pollution. This leads to increased amount of plant and algal growth, which damages the aquatic life and ecosystem of the water bodies. Water bodies under such condition are on the verge of depletion and requires higher level of intervention.

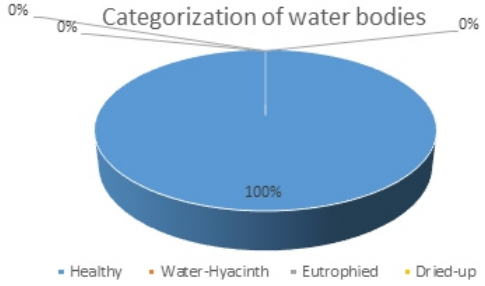


Figure 4.34: Categorization of water bodies in Dehradun

The study found that the water body was Healthy.

Turbidity

Turbidity test was undertaken for 44 water bodies of Dehradun district, as per the availability of water.

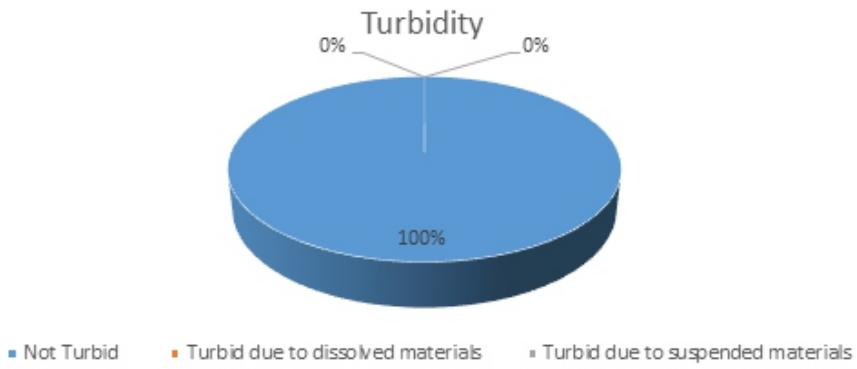


Figure 4.35: Turbidity in water bodies of Dehradun

As per , 100 per cent of the water bodies came out to be 'Not Turbid' that denotes clear and transparent water which is good for usage and health of habitat situated nearby.

Settlement near water bodies

Figure 4.36 depicts block-wise 'Percentage distribution of Settlement' found in Dehradun district. 100% accountability has been captured under 1 block with a count of 1 water bodies, having settlement present within 200-250 meters of its radius.

Settlement was found near the only water body.

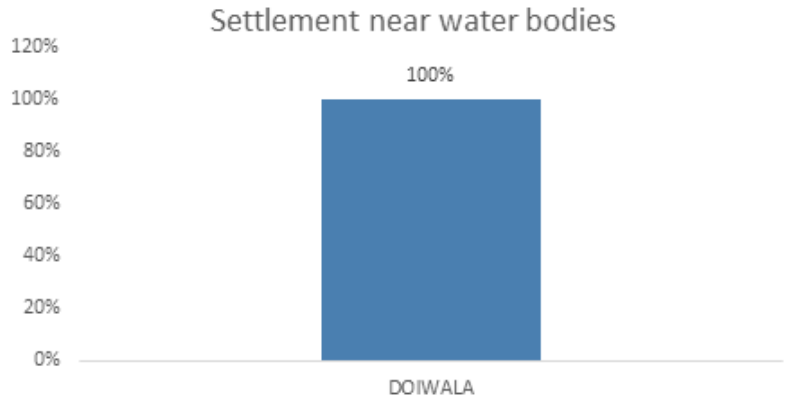


Figure 4.36: Settlement near water bodies in Dehradun

Figure 4.36 configures only one type of settlement that is Residential households.

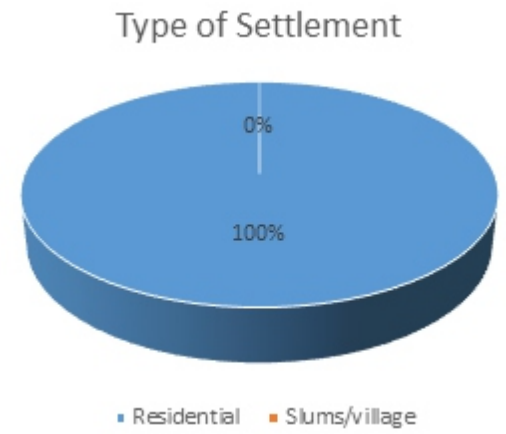


Figure 4.37:Type of Settlement around water bodies in Dehradun

Type of settlement plays a major role in determining the catchment yield of a water body. Difference in type and load of pollutants was observed through a Slum area and a Residential area. For example: Animal dung, chemical/fertilizers from Slum/village area becomes the cause of pollution in water bodies and on the other hand Solid waste, Silt from under-construction sites in Residential areas are the causes of contamination. However, in exceptional cases the load of pollutants entering into a water body may not vary as per our Project Expert.

Wastewater drainage and Solid waste

Pie-chart, Figure 4.38 represents Wastewater drainage was not present near the water body assessed in Dehradun. The water body did not get contaminated through wastewater drainage as a cause of direct run-off.

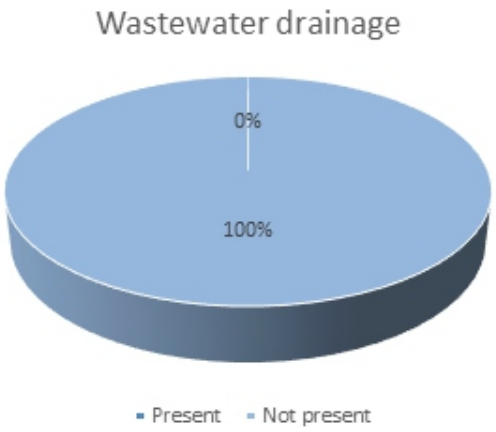


Figure 4.38: Wastewater drainage in and around water bodies in Dehradun

The water body was not found to have any solid waste disposal in and around the water body.

Wastewater drainages present in residential area settlements may cause accumulation of solid waste near and on the surface of water bodies. Screens/mesh/bars restricts solid waste from entering into the water body. However, pollutants which enters the water bodies along with the solid waste and wastewater drainages deteriorate the quality of water present in it. Excessive nutrients like Phosphorus and Sulfur coming from these non-point sources of pollution leads to eutrophication, which damages the overall health of the water bodies.

DISTRICT SCORECARD: DEHRADUN

Block-wise scores and Descriptors

Below is a tabular representation of the score acquired by Doiwala block of Dehradun.

Rank	Block	Score	Descriptors
1	Doiwala	200.0	Good

Table 11: Ranking of Blocks in Dehradun based on scores

Scores have been summarized on the basis of all the seven indicators which were considered as the key factors for evaluation of the water bodies out of a total marks of 300.

On the basis of performance, it was found that water body present in Doiwala block of Dehradun stands with an average score of 200 out of 300. The resultant score indicates a 'Good' performance by Dehradun district.

Indicator-wise scores of Dehradun

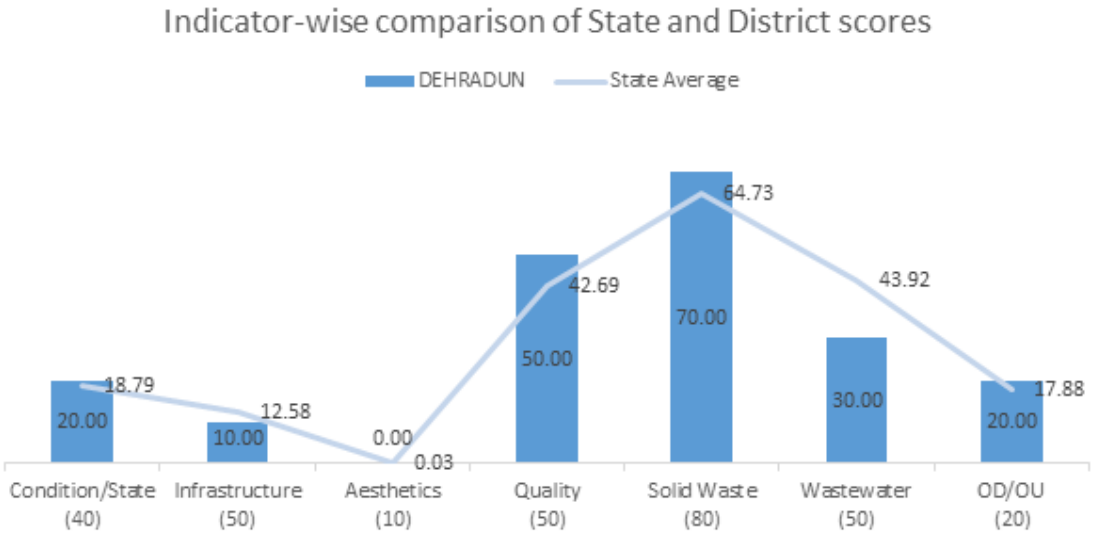


Figure 4.39: Indicator-wise scores of Dehradun

Above bar graph represents the overall score of Dehradun district. Evaluation of scores and grades was done on the basis of seven key indicators mentioned below:

1. **Functionality,** which play a significant role in determining overall health a water body and the reason for its rejuvenation or depletion. Factors affecting the functionality of water bodies are types of settlement and septic tanks present near them.
2. **Infrastructure** signifies the physical structure of a water body, which includes the condition of fencing, road connectivity around the water body and outlet channel to ensure drain-out of overflow. This indicator plays a vital role in resolving the issue of water bodies being dried-up.
3. **Aesthetics (Aesthetic enhancement)** includes beautification around the water bodies, which includes benches, religious architectures, sheds, grass/gardening, etc.
4. Quality as an indicator comprise of factors like turbidity status, eutrophication, and formation of foam, which comprehends the severity in terms of quality of water present in a water body.
5. **Solid Waste** includes waste present around/on the surface of water bodies. It checks on factors like availability of the dustbins, flies over the Garbage Vulnerable Points (GVPs) and leachate coming out from it, which might directly contaminate a water body.
6. **Wastewater** includes the status and type of drainage run-off and direct contamination of water body due to it.
7. **OD/OU** indicator indicates the presence of the human faecal matter, animal dung and urination around water body. It acts as a major role behind the growth of algae and plants into the water body.

The line graphs depicts indicator-wise State average of the survey and the bar graph represents the indicator wise scores of Dehradun district.

- In terms of Aesthetics, Dehradun maintains the mean score corresponding to the State score.
- Whereas, in terms of Condition/State, Quality, Solid waste disposal and OD/OU, score of Dehradun is better than the State score.
- However, Dehradun performed poorer than the State in terms of Infrastructure and Wastewater drainage.

Performance based descriptors of Dehradun

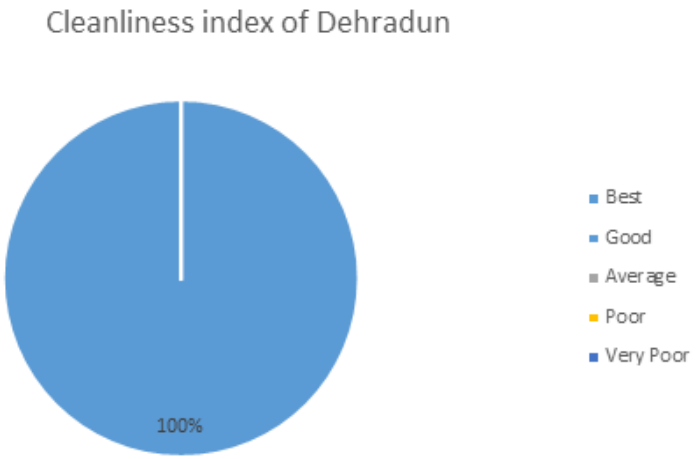


Figure 4.40: Cleanliness index of Dehradun

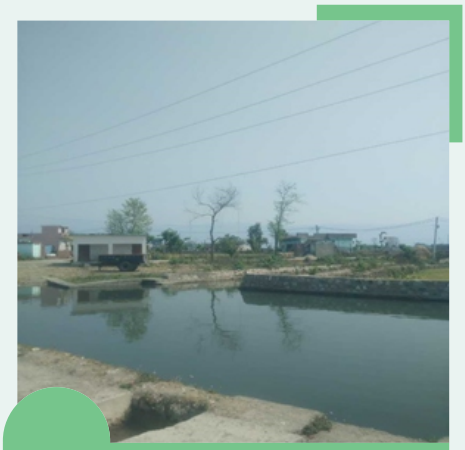
Water bodies found in Dehradun were lying under different descriptors as per their performances. These descriptors are characterized by different water body indicators, which denotes water body Cleanliness Index.

'Best' and 'Good' indicates that lower level of intervention is required, whereas, 'Poor' and 'Very Poor' signifies that higher level of intervention is needed for rejuvenation and sustainability of a water body. Furthermore, medium level of intervention is required for water bodies lying under 'Average' category.

As per the figure, the water body falls under 'Good' category in the index, which requires less of revival and more of sustainability.

Images of water bodies in DEHRADUN

Healthy
UK_GOHRI MAFI_45352_011601_W1



Encroachment
UK_GOHRI MAFI_45352_011601_W1

Outlet (Stone pitching)
UK_GOHRI MAFI_45352_011601_W1

Not Turbid
UK_GOHRI MAFI_45352_011601_W1

No solid waste inside
UK_GOHRI MAFI_45352_011601_W1

No solid waste around
UK_GOHRI MAFI_45352_011601_W1

No aesthetic enhancement found
UK_GOHRI MAFI_45352_011601_W1

No Open defecation
UK_GOHRI MAFI_45352_011601_W1

4.1.4.4 District Report: Haridwar

Configuration

The following bar graph represents the count of water bodies along with the number of villages assessed in a particular block.

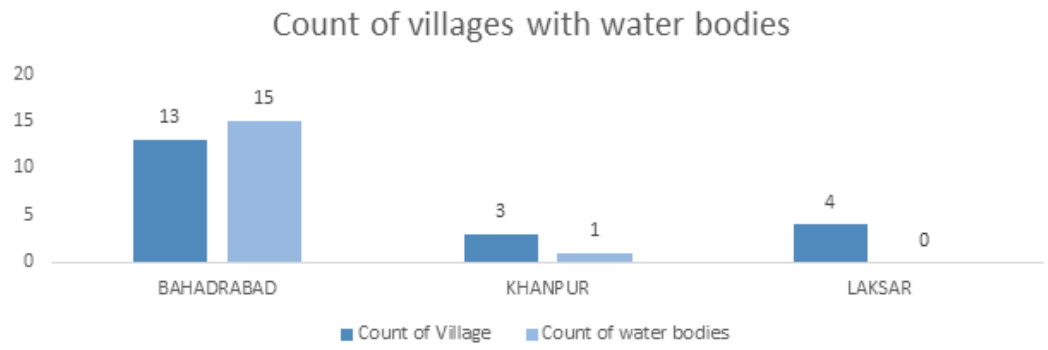


Figure 4.41: Count of villages in Haridwar with water bodies

Two blocks of Haridwar district were found to have water bodies within Ganga basin. 16 water bodies were identified during the survey of 20 villages in Haridwar.

- Only 1 water body was found in 3 villages of Khanpur block.
- Maximum count of water bodies as 15, were identified during the survey of 13 villages in Bahadrabad.

No water bodies were found in Laksar block. Hence, no parameters could be assessed for Laksar.

Categorization of the water bodies

Water bodies have been categorized in four groups based on their status: Healthy, Water-Hyacinth, Eutrophication, and Dried-up.

A water body is categorized as **Healthy** if the general appearance is clean and traces/layer of algae is not present in it.

Presence of **Water-hyacinth** is safe for the water bodies until it is present in controlled amount. This plant requires threshing to prevent blockage, so that sunlight could reach the water body bed and it does not become a home for disease-carrying mosquitoes.

A **dried-up** water body indicates that the catchment yield and inlet systems for its replenishment are not active or blocked.

Eutrophication is caused due to presence of excessive nutrients like Phosphorous and Sulphur in water bodies, which can enter through non-point sources of pollution. This leads to increased amount of plant and algal growth, which damages the aquatic life and ecosystem of the water bodies. Water bodies under such condition are on the verge of depletion and requires higher level of intervention.

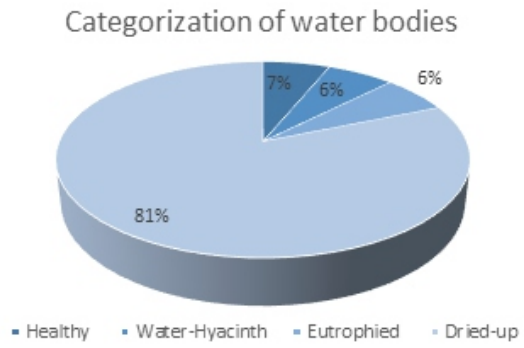


Figure 4.42: Categorization of water bodies in Haridwar

The study found that 81 per cent of the total water bodies fall under Dried-up category and 6 per cent were Eutrophied. In addition, 6 per cent of the total water bodies had Water hyacinth present in them.

Hence, proportion of water bodies lying under Healthy category was found to be comparatively low, which is a sign of poor catchment yield and lack of awareness among the locals.

Turbidity

Turbidity test was undertaken for 5 water bodies of Haridwar district, as per the availability of water.

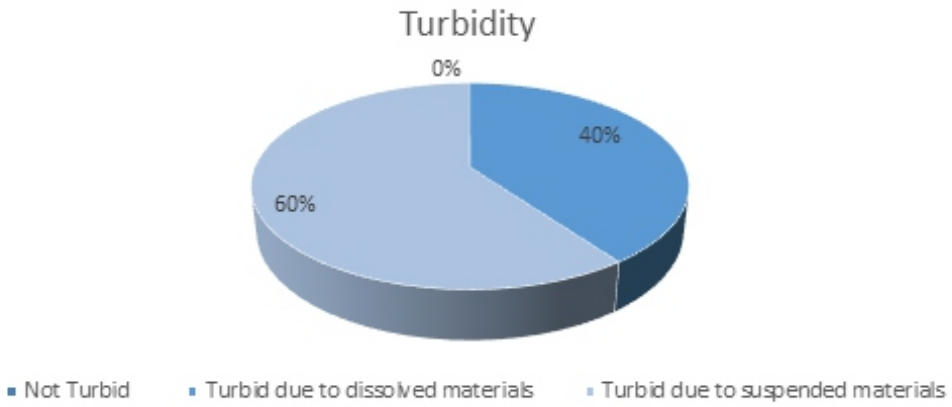


Figure 4.43: Turbidity in water bodies of Haridwar

As per Figure 4.43, No water body came out to be 'Not Turbid' that denotes clear and transparent water which is good for usage and health of habitat situated nearby.

Whereas, 60 per cent of the water bodies were found as 'Turbid due to Suspended material' which contains heavy particles of silt and thick traces of algae. In addition, 40 per cent of them hold their status as 'Turbid due to dissolved material' that contains a major proportion of mud and silt.

Settlement near water bodies

Figure 4.44 depicts block-wise 'Percentage distribution of Settlement' found in Haridwar district. 100% accountability has been captured under 1 block with a total count of 12 water bodies, having settlement present within 200-250 meters of its radius.

No settlement was available near water bodies, which were found in Khanpur block.

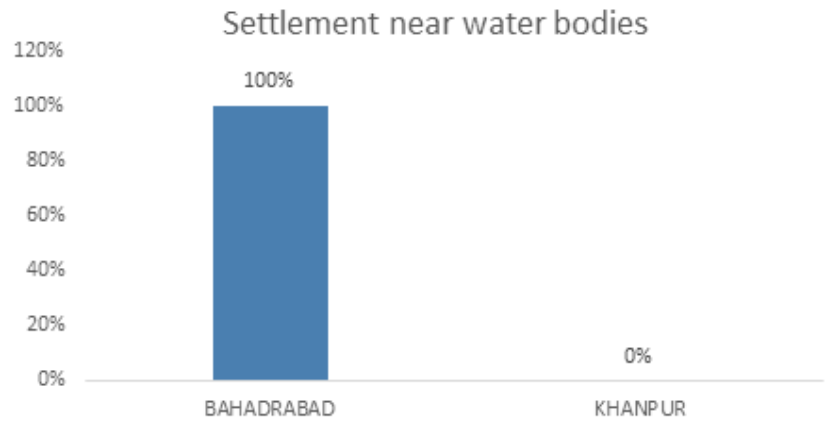


Figure 4.44: Settlement near water bodies in Haridwar

Firure 4.45 configures two types of settlement, which denotes that Slums/village has 8 per cent occupancy and 92 per cent of the water bodies were surrounded by Residential households.

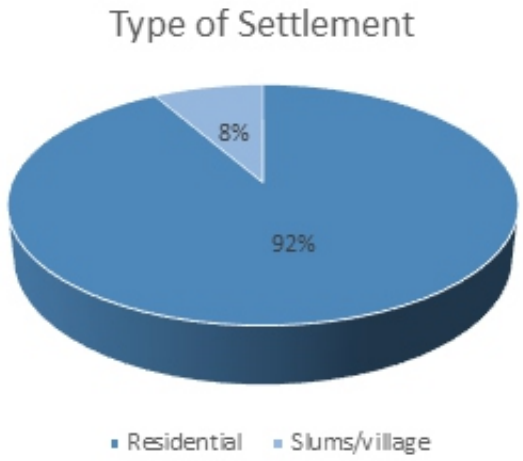


Figure 4.45: Type of Settlement around water bodies in Haridwar

Type of settlement plays a major role in determining the catchment yield of a water body. Difference in type and load of pollutants was observed through a Slum area and a Residential area. For example: Animal dung, chemical/fertilizers from Slum/village area becomes the cause of pollution in water bodies and on the other hand Solid waste, Silt from under-construction sites in Residential areas are the causes of contamination. However, in exceptional cases the load of pollutants entering into a water body may not vary as per our Project Expert.

Wastewater drainage and Solid waste

Pie-chart, Figure 4.46 represents Wastewater drainage present near water bodies assessed in Haridwar, where 25 per cent of the water bodies get contaminated through wastewater drainage as a cause of direct run-off.

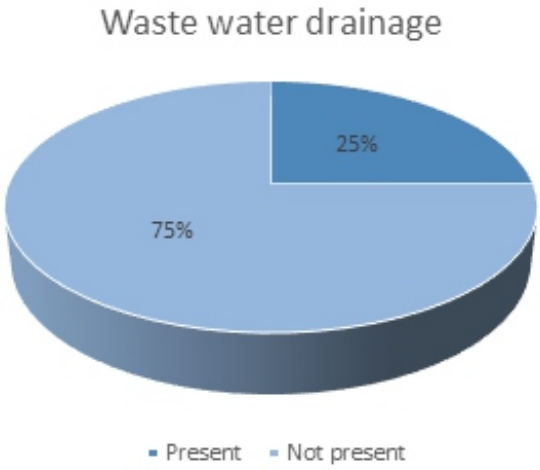


Figure 4.46: Wastewater drainage in and around water bodies in Haridwar

As per Figure 4.47, it was observed that,

- Bahadrabad accounts for 100 per cent of water bodies having solid waste present in/around them.
- Hence, no solid waste was present in/around the water bodies found in Khanpur.

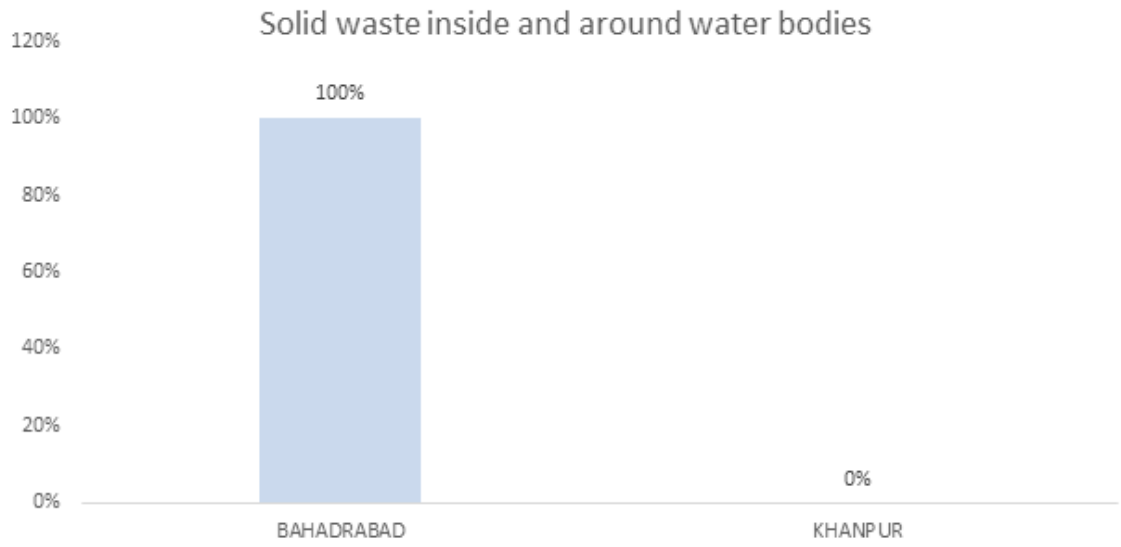


Figure 4.47: Solid waste inside and around water body in Haridwar

Wastewater drainages present in residential area settlements may cause accumulation of solid waste near and on the surface of water bodies. Screens/mesh/bars restricts solid waste from entering into the water body. However, pollutants which enters the water bodies along with the solid waste and wastewater drainages deteriorate the quality of water present in it. Excessive nutrients like Phosphorus and Sulfur coming from these non-point sources of pollution leads to eutrophication, which damages the overall health of the water bodies.

DISTRICT SCORECARD: Haridwar

Block-wise scores and Descriptors

Below is a tabular representation of the scores backed by each block of Haridwar along with its grade and rank.

Rank	Block	Score	Descriptors
1	Khanpur	205.0	Good
2	Bahadrabad	163.0	Average

Table 12: Ranking of Blocks in Haridwar based on scores

Graphical representation of Block-wise scores of Haridwar

Scores have been summarized on the basis of all the seven indicators which were considered as the key factors for evaluation of the water bodies out of a total marks of 300.

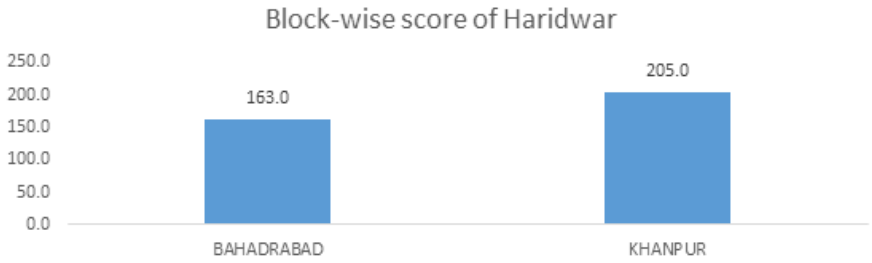


Figure 4.48: Block-wise score of Haridwar

On the basis of performance, it was found that water bodies present in various blocks of Haridwar stands with an average score of 184 out of 300. The resultant score indicates a 'Good' performance by Haridwar district.

Khanpur tops the chart among other 2 blocks, by obtaining an average score of 205 out of 300. Whereas, Bahadrabad has acquired an average score of 163.

Indicator-wise scores of Haridwar

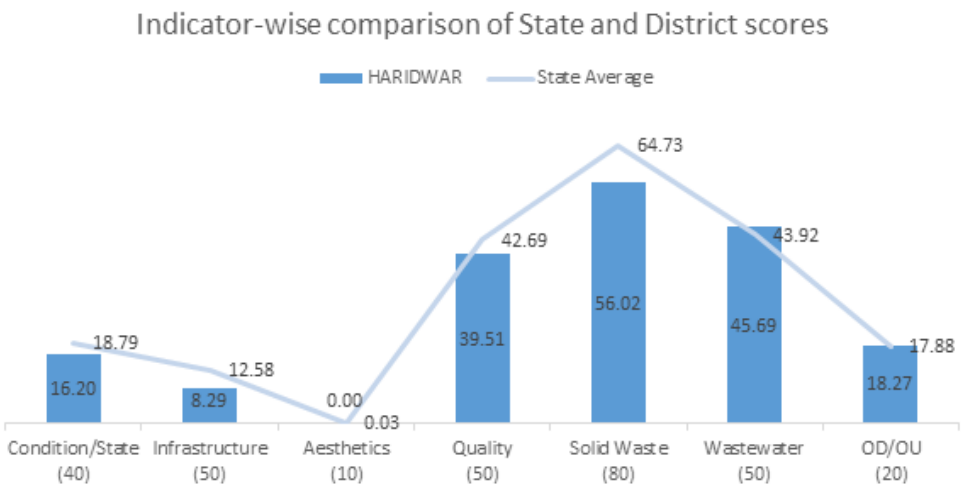


Figure 4.49: Indicator-wis scores of Haridwar

Above bar graph represents the overall score of Haridwar district. Evaluation of scores and grades was done on the basis of seven key indicators mentioned below:

1. **Functionality,** which play a significant role in determining overall health a water body and the reason for its rejuvenation or depletion. Factors affecting the functionality of water bodies are types of settlement and septic tanks present near them.
2. **Infrastructure** signifies the physical structure of a water body, which includes the condition of fencing, road connectivity around the water body and outlet channel to ensure drain-out of overflow. This indicator plays a vital role in resolving the issue of water bodies being dried-up.
3. **Aesthetics (Aesthetic enhancement)** includes beautification around the water bodies, which includes benches, bridges, religious architectures, sheds, grass / gardening, etc.
4. **Quality** as an indicator comprise of factors like turbidity status, eutrophication, and formation of foam, which comprehends the severity in terms of quality of water present in a water body.
5. **Solid Waste** includes waste present around/on the surface of water bodies. It checks on factors like availability of the dustbins, flies over the Garbage Vulnerable Points (GVPs) and leachate coming out from it, which might directly contaminate a water body.
6. **Wastewater** includes the status and type of drainage run-off and direct contamination of water body due to it.
7. **OD/OU** indicator indicates the presence of the human faecal matter, animal dung and urination around water body. It acts as a major role behind the growth of algae and plants into the water body.

The line graphs depicts indicator-wise State average of the survey and the bar graph represents the indicator wise scores of Haridwar district.

- In terms of Aesthetics and OD/OU, Haridwar maintains the mean score corresponding to the State score.
- Whereas, in terms of Wastewater drainage, score of Haridwar is better than the State score.
- However, Haridwar performed poorer than the State in terms of Condition / State, Infrastructure, Quality and Solid waste disposal.

Performance based descriptions of Haridwar

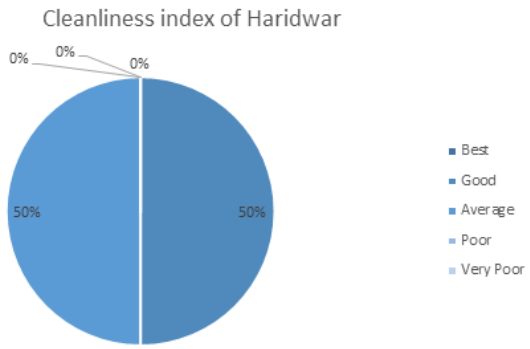


Figure 4.50: Cleanliness index of Haridwar

Water bodies found in various blocks of Haridwar were lying under different descriptors as per their performances. These descriptors are characterized by different water body indicators, which denotes water body Cleanliness Index.

'Best' and 'Good' indicates that lower level of intervention is required, whereas, 'Poor' and 'Very Poor' signifies that higher level of intervention is needed for rejuvenation and sustainability of a water body. Furthermore, medium level of intervention is required for water bodies lying under 'Average' category.

As per the figure, 50 per cent of the water bodies fall under 'Good' which requires less of revival and more of sustainability. Whereas, other 50 per cent of water bodies lie in the Average band. These require medium level of intervention for rejuvenation.

Images of water bodies in HARIDWAR

Healthy UK_MISSARPUR MUST_*56709_011703_W3

Dried up UK_KATARPUR ALIPUR_56721_011663_W3

Water Hyacinth (Duckweed) UK_KISHANPUR JHARARA AHTMAL_*56711_011641_W1

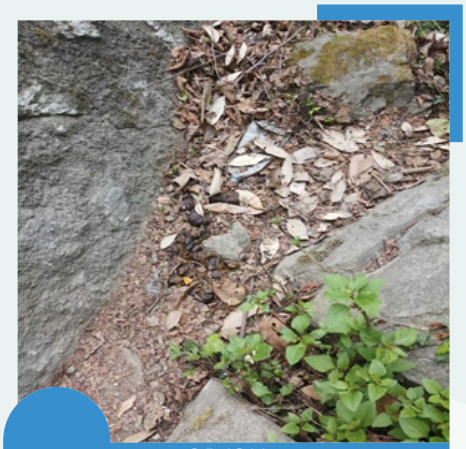
Eutrophied UK_MOHD.BEGAMPUR URF TAKABHARI_*56650_011681_W1

Settlement UK_KATARPUR ALIPUR_56721_011661_W1

Turbid due to dissolved materials UK_KISHANPUR JHARARA AHTMAL_*56711_011641_W1

Waste Inside UK_KATARPUR ALIPUR_56721_011662_W2

Thick layer of algal bloom UK_MOHD.BEGAMPUR URF TAKABHARI_*56650_011681_W1



OD/OU UK_VAINOLI_Tmp512881_027452_W2

A. ANNEXURE DETAILS

a. Detailed Scoring Toolkit

Category	Sub Category	Question	Options	Updated Marks Breakup	Updated Total Marks
Water Body Index	Condition / State	Does the water body have adequate water (not dried up)?	Yes	10	10
			No	0	
		Does the area around the water body has any settlement?	Yes	0	20
			No	20	
		Do you see any septic tank within 100m of the water body	Yes	If Yes, then following scoring	10
			No	10	
		If yes, How far is the septic tank located?	10-30	0	
			30-50	0	
			50-100	5	
	Infrastructu-re	Do you see any fencing around the water body	Yes	If Yes, then following scoring	20
			No	0	
		If yes, What is the condition of fencing?	Complete fencing	20	
			Partially fenced	15	
			broken	10	
		Is there any Outlet channel in the water body?	Yes	10	10
			No	0	
		What is the condition of Outlet channel?	Clear	10	
			Partially Blocked	5	
			Blocked	0	
		Is there any road connected or near to the circumference of waterbody?	Yes	0	10
			No	10	

Category	Sub Category	Question	Options	Updated Marks Breakup	Updated Total Marks
		Is there a CT/PT near the water body?	Yes	0	5
			No	5	
		Is the disposal system of the CT/PT connected into water body?	Yes	0	5
			No	5	
	Aesthetics	Any kind of aesthetic enhancement done around the waterbody?	Yes	If Yes, then following scoring	10
			No	0	
		what kind of aesthetic enhancement do you see around the waterbody	A park	2	
			Just a few benches	2	
			Floral beautification	2	
			A footbridge	2	
			Religious architecture	2	
	Quality	Turbidity of the water	Turbid due to suspended materials	5	10
			Turbid due to dissolved materials	0	
			Not turbid	10	
		Is the water body Eutrophied?	Yes	0	20
			No	20	
		What type of Eutrophication in the water body?	Traces of Algal blooms in the water body	10	
			A thin layer of Algal blooms	5	

Category	Sub Category	Question	Options	Updated Marks Breakup	Updated Total Marks
			A thick green layer of Algal bloom and slime (blocking sunlight)	0	
		Do you see any foam on the surface of the water body	Yes	0	20
			No	20	
		If Yes, what is the volume of foam?	Foam present at only one checkpoint	10	
			Foam present at two checkpoints	6.7	
			Foam present at three checkpoints	3.3	
			Foam present at all checkpoints	0	
	Solid Waste	Do you see any kind of waste around the water body?	Yes	0	20
			No	20	
		If Yes	Present around only one checkpoint	10	
			Present around two checkpoints	6.7	
			Present around three checkpoints	3.3	
			Present around all checkpoints	0	
		Do you see leachate coming out of the dump	yes	0	20
			no	20	

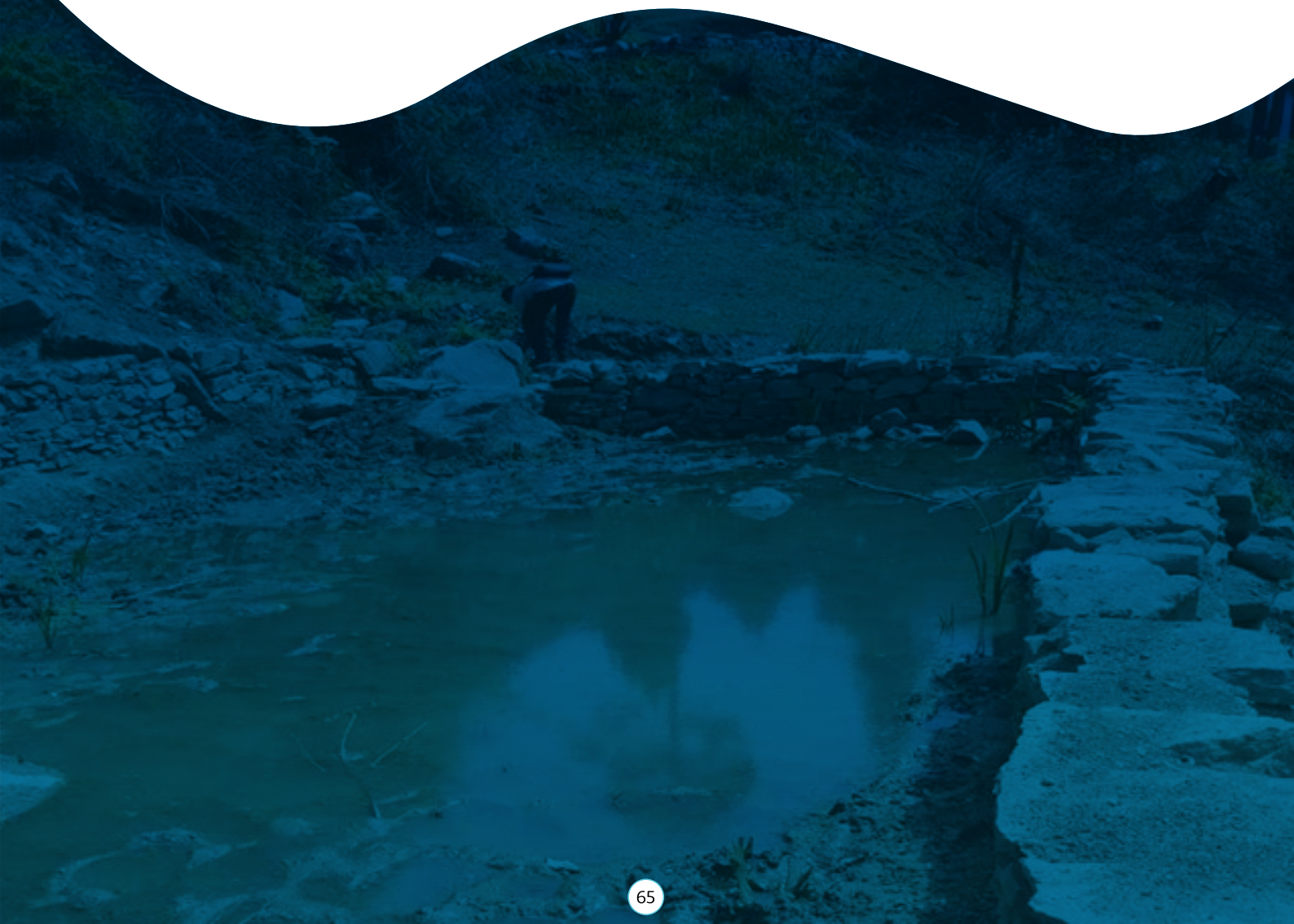
Category	Sub Category	Question	Options	Updated Marks Breakup	Updated Total Marks
		If Yes, Is leachate following into the water body?	Yes	0	
			No	10	
		Do you see any dustbins around the waterbody	Yes	10	10
			No	0	
		Do you see flies around the dump	Yes	0	10
			No	10	
		Do you see any waste on the surface of the water body?	Yes	0	20
			No	20	
		If yes	Present at only one checkpoint	10	
			Present at two checkpoints	6.7	
			Present at three checkpoints	3.3	
			Present at all checkpoints	0	
	Wastewater	Does any kind of washing take place (50m) around the water body?	Yes	0	20
			No	20	
		Do you see any kind of wastewater drain	Yes	If Yes, then following scoring	30
			No	30	
		If yes	Drainage into the waterbody	0	
			Drainage around the waterbody	10	
		Do you see screen mesh/grill/net at the opening of the drainage	Yes	10	
			No	0	

Category	Sub Category	Question	Options	Updated Marks Breakup	Updated Total Marks
	OD/OU	Do you see any human feacal matter or animal dung around the waterbody	Yes	0	20
			No	20	
		If yes	Present around only one checkpoint	10	
			Present around two checkpoints	6.7	
			Present around three checkpoints	3.3	
			Present around all checkpoints	0	

b. Standard operating Procedure: Aerial Survey of water bodies

STANDARD OPERATING PROCEDURE FOR DRONE ASSESSMENT (AERIAL SURVEY)

QUALITY COUNCIL OF INDIA	Date:	10th March 2021
	Document Number:	QCI-SOP-DS-0002
	Version:	2.0
STANDARD OPERATING PROCEDURE FOR AERIAL SURVEY OF WATER BODIES USING DRONES	Prepared By:	
	Reviewed By:	
	Approved By:	
	Authorized signatory:	



1. Objective

1.1 General

A drone survey refers to the use of a drone, or unmanned aerial vehicle (UAV), to capture aerialdata with downward-facing sensors. During a drone survey with an RGB camera, the water body is photographed several times from different angles, and each image is tagged with coordinates. This report presents the technical information about the survey aspects of the project located in India.

1.2 Scope of Work

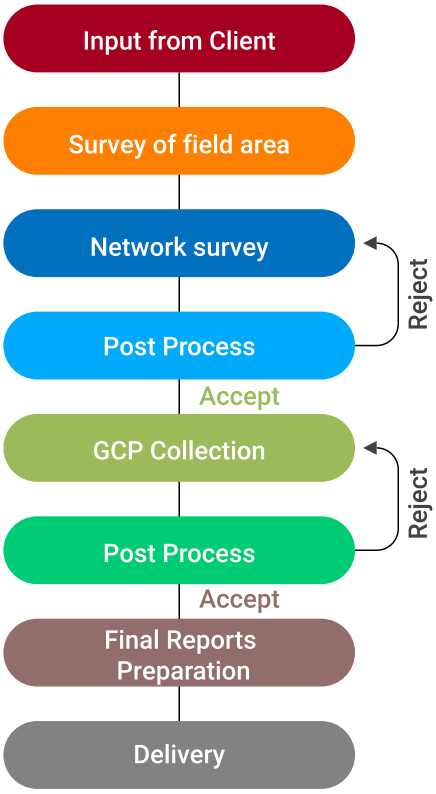
The objectives of the drone survey are as follows:

- Data acquisition
- Data processing
- Topo drawing (Contour Mapping)
- Area of the water body

1.3 Methodology

The methodology adopted for the drone survey is data acquisition using drone to get data in the form of images will be acquired by the drone. Check points are laid to improve the accuracyof the dataset. Photogrammetry combines images that contain the same point on the ground from multiple vantage points to yield detailed 2D and 3D maps.

2. Process flow



2.1 Drone Survey

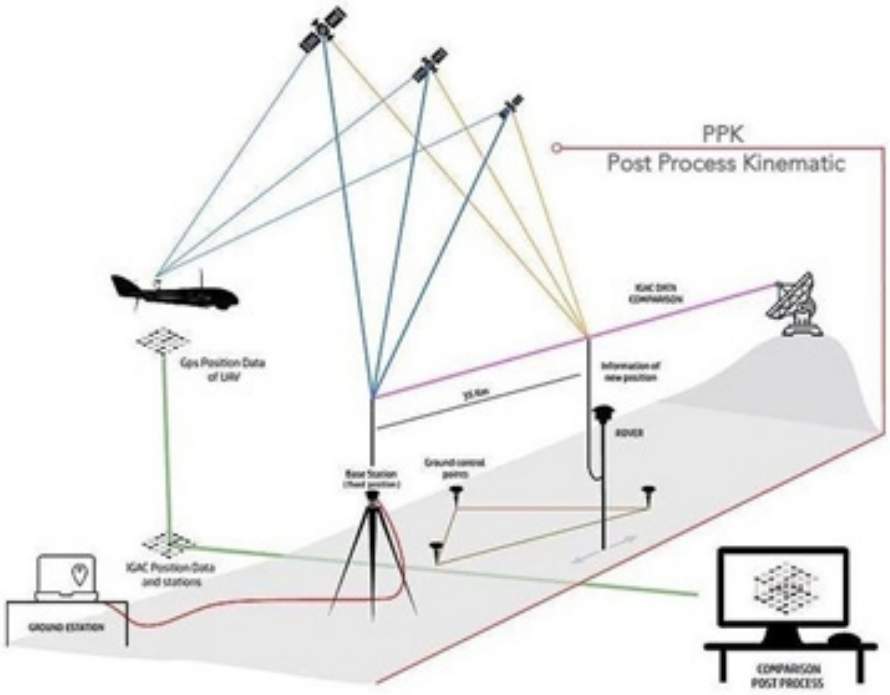
Most of the photogrammetry and LiDAR surveys requires a lot of Ground Control Points (GCPs) to georeferenced the data accurately. But with the GNSS PPK (Post Processing Kinematics) technology which is very scientifically integrated with the Skylark's UAS platforms, the need of Ground Control Points (GCPs) is reduced by 90% and the rest of the 10% of the GCPs will be used to transform the geographical coordinate system to another reference plane and for ensuringthe accuracy levels. Every time an image is captured, the system provides very high precision camera position. This provides a whole trajectory of the image capturing coordinates of the camera, which can be used at real time or during the post processing time. The system requires two units, one of the units is base station and other is called as rover, which in this case will be UAS. The base station and rover will be continuously connected with each other as well with the GPS and GLONASS satellites. PPK provides centimeter level accuracy. Eventually, with PPK system following advantages can be observed when compared to very conventional method of justusing Ground Control Points (GCPs) to obtain accuracy:

1. Better absolute accuracy (5-7 cm in X, Y and 8-10 cm in Z) wherein only using GCPs limitsthe accuracy in Z to 15-20 cm

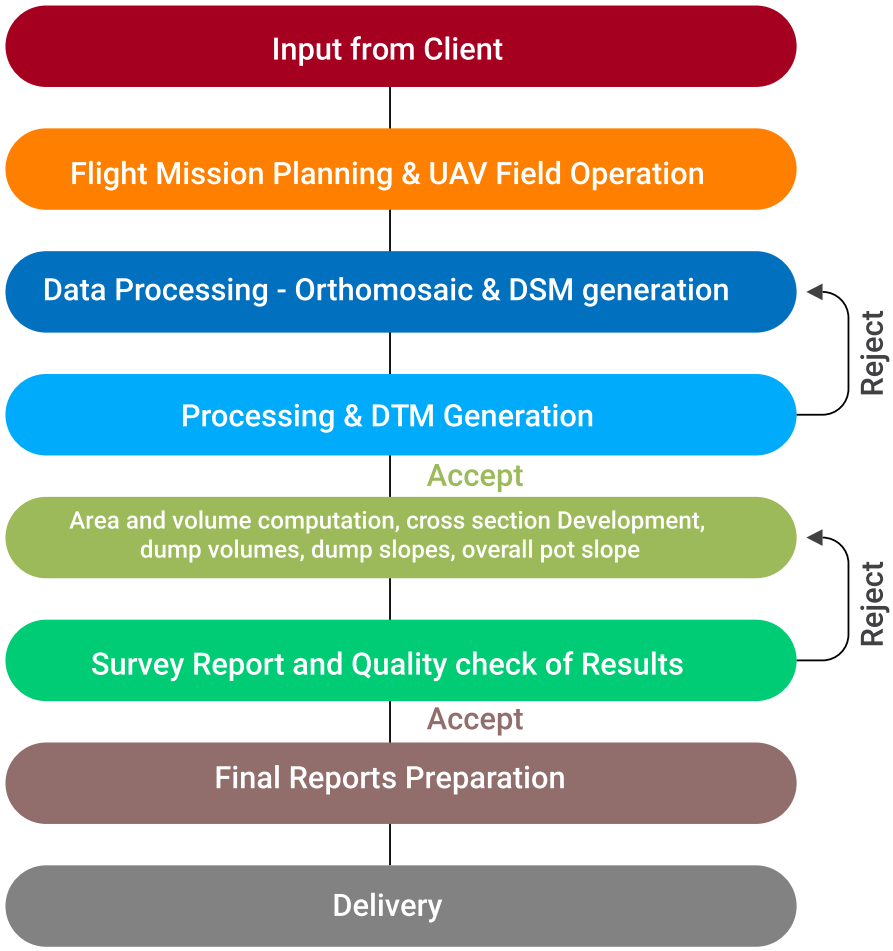
2. Lower number of GCPs (only 3-4) whereas avg. 7-8 GCPs are required per 100 Hectare when PPK is not used.

3. Consistent accuracy throughout the area whereas in case of only GCP approach, accuracies (10-12cm) are concentrated around the GCPs and deviates in areas away from GCPs

4. Lower processing time as PPK geo-tag enables faster alignment of images and does not relyonly on image feature identification-based alignment which consumes multiple times higher time.



Process Flow



2.2 Accuracies achieved in Photogrammetry

In photogrammetry, accuracy depends majorly on the following factors:

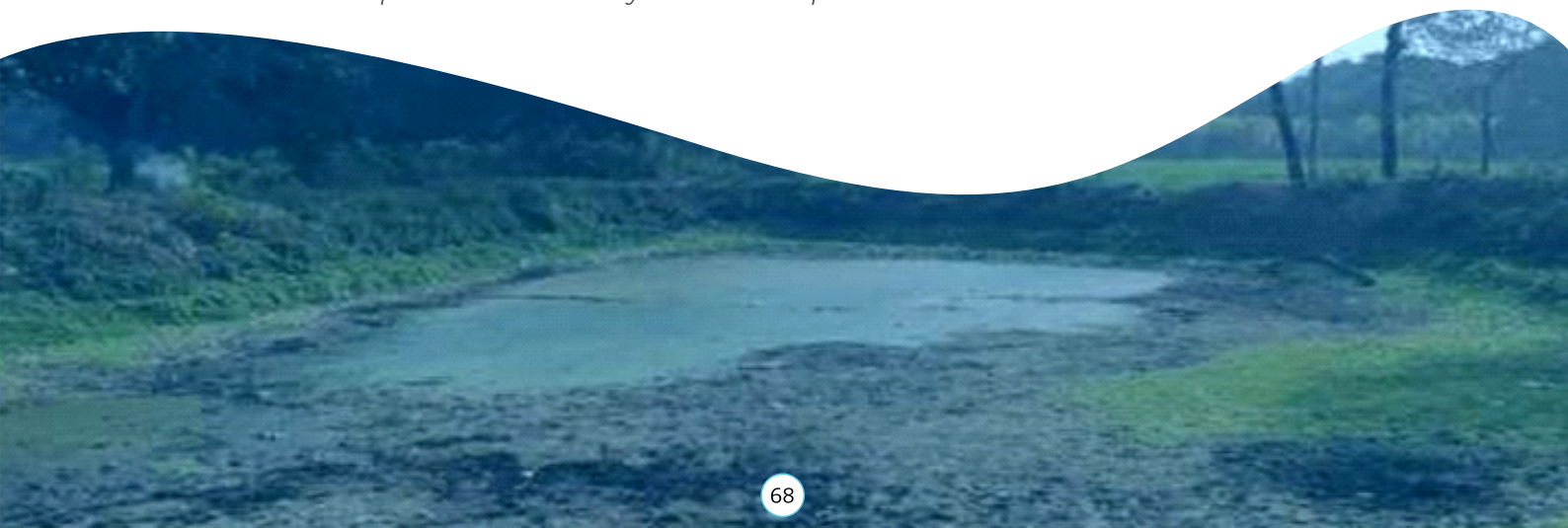
- Scientific practices (GCP placement, Path planning etc.,)
- Image resolution
- Image position accuracy
- Flying conditions
- Ground Control Point accuracy
- Data processing practices

Unlike manned aircraft, which cannot fly at low altitudes, UASs can provide fantastic image resolutions even with simple digital camera. If all the above factors are carefully tackled, the accuracies can be as good as 3-4 cm in in X, Y plane and 5-6 cm in Z plane using the photogrammetry technique. To achieve these accuracies, we at Skylark follow extremely scientific methods which include extensive new age research and methodologies of our own. A lot of on-board UAS sensor data (viz., attitude, location, state etc.,) are continuously stitched with images to obtain survey grade results and accuracies.

PPK Technology Vs Ground Control

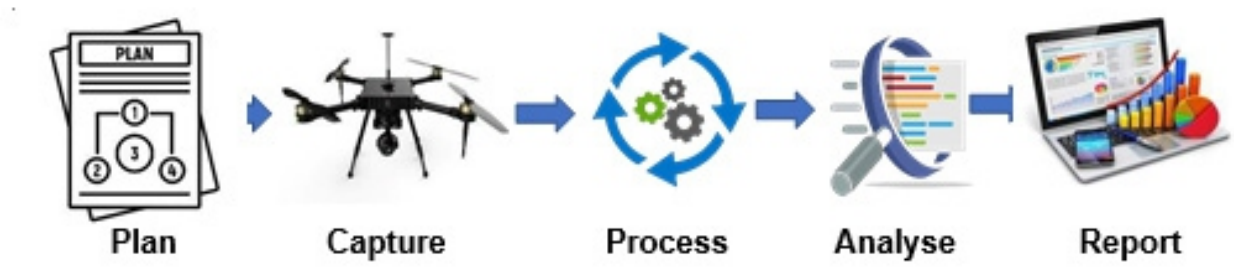
Parameter	Non PPK Drone	PPK Enabled Drone	Advantage
X, Y and Z Absolute Accuracies without GCP's	>50 cm	7-9 cm in X and Y, 12-15 cm in Z	Better accuracies without GCP's
Best Accuracies with GCP's	5-10 cm in X and Y, 10-15 in Z	3-4 cm in X and Y, 7-8 cm in Z	Up to 2times better accuracies with GCP's
Number of GCP's per Sq. Km for above accuracies	8-10	1-2	Less dependency on other factors and more area coverage per day
Relative Accuracies	Higher Accuracy near the GCP, Accuracy decreases as we move farther	Accuracies remain same through the data irrespective of GCP's	For large areas PPK is more useful than any other technology

Table: Comparison of accuracy and GCP requirements for PPK and Non-PPK drone



2.3 The Typical UAV Workflow

A typical survey workflow for photogrammetry using a Drone/UAS appears following:



2.4 Preflight Checklist

Pre-Flight Checklist	Version	Revision
Project Code	Date	Client
PM/TL/PIL/GCS	Mission Id	UAV ID
Parameter	**Checklist/Value**	**Remarks**
UAV Preparation		
Landing time		
Disarm UAV by push safety button switch		
Plug out the battery		
Turn off the RC Transmitter		
Disconnect Mission Planner from drone		
Launcher Preparation		
Distance travelled		
Flight time		
Battery ID		
Camera Battery ID		
Battery Preparation		
Weather condition		
Temperature	%	
Altitude	V	
Wind Speed	V	
Camera Preparation		
Camera ID		
Camera Battery ID		
Camera SD Card ID		
Camera condition is good, and setting is adjusted		
Battery camera level>50%	%	
Memory card is empty and inserted		
Lens and UV filter are cleaned properly		

Camera active gimbal structure is good		
Camera is installed on UAV and connected to the system		
GCS Preparation		
Computer Battery is sufficient >50%	%	
Modem is positioned properly		
Mission planner software is working properly		
Flight Mission		
Waypoints position and height are correct		
Mission length <70 km	km	
Mission altitude > 200 m	m	
Final Preparation		
Turn on UAV by plug in battery		
Mission Planner is connected with telemetry signal > 90%		
Current mission uploaded		
Set camera mount to "Neutral" mode		
Camera trigger system is checked		
MP Battery percentage indicator >95%	%	
MP Battery voltage indicator >16.5 v	V	
GPS satellite count >7 sat	sat	
HDOP value is sufficient <2.0		
IMU indicator is good		
UAV is mounted to the launcher with roll orientation to launcher <2°		
UAV mount no-slip at 100% throttle and rotary direction is checked		
All servos respond to roll, pitch and deflection is		
checked		
UAV's mode "FBW-A"		
Take-off direction adjusted to headwind		
Take-off time		
Condition		
Weather condition		
Temperature	°C	
Humidity	%	
Pressure	mmHg	
Altitude	m	
Wind Speed	m/s	
Wind Direction	°	
UAV Condition		
Additional Remark and Illustrations		

2.4 Preflight Checklist

Pre-Flight Checklist	Version	Revision
Project Code	Date	Client
PM/TL/PIL/GCS	Mission Id	UAV ID
Parameter	Checklist/Value	Remarks
Recovery and Preparation		
Landing time	:	
Disarm UAV by push safety button switch		
Plug out the battery		
Turn off the RC Transmitter		
Disconnect Mission Planner from drone		
Release the camera from housing		
Copy all the photos to GCS		
Parameters		
DAN/OAN		
Distance travelled	km	
Flight time	min	
Battery ID		
Camera Battery ID		
Camera Battery percentage	%	
Camera SD Card ID		
Number of photos		
Condition		
Weather condition		
Temperature	°C	
Altitude	m	
Wind Speed	m/s	
Wind Direction	°	
UAV Condition		
TL:	**GCS:**	**REMARKS:**

2 Procedure

3.1 Data Acquisition Using Drone

3.1.1 General

To obtain good images suitable for processing, it is very important to design a data acquisitionplan considering: type of project (aerial, terrestrial, mixed), type of terrain / object, type of camera, purpose of the project, image rate that the images are taken, distance (flight height) atwhich the images are taken and with which angle to take the images, path(s) to follow to take the images, etc.
For aerial projects, this also implies selecting corridor path or regular grid and/or circular grid, deciding whether terrestrial images will be used, if more than one flights are needed to cover the full area.

3.1.2 Mission Planning

A data acquisition plan is made specific to the site that needs to be surveyed. It depends on the type of terrain / object to be reconstructed. Flight polygons are designed, and data acquired is as per this plan. The flying altitude is designed to capture resolution which best fits the project.

Table 1: Details of Mission Plan

Parameters	Details
Drone Phantom	4 RTK
Flying Altitude	50 - 100 m
Ground Sampling Distance	1.0 - 2.0 cm
Overlap (%)	70/70
Data type	RGB images

Planning involves fixing AOI, placing GCP's across the AOI, and fixing the flight parameters such as Ground Sampling Distance (GSD) or spatial resolution, Frontal overlap, Side overlaps according to project requirements.

Figure: Drone AOI with GCP placement

3.1.3 Check Points Planning

Check Points (CP) are markers laid on the ground which will be incorporated in the photogrammetry processing to improve the accuracy of the dataset. Distance between them isobtained with traditional surveying methods in the field. CPs are necessary for orientation andplacement of aerial photographs in the spatial coordinate system.

Figure: Sample GCP, placement on ground and taking reading on it

3.1.4 Field Data Collection:

DGPS Survey:

Data Collection involves preliminary reconnaissance survey around the AOI for placing GCP's. Once the GCP's were placed DGPS survey will be conducted to observe the placed GCP's.

Figure: GCP Banner from Field Survey

3.1.5 Drone Data Collection:

Base will be established to collect drone data. Drone will be flown from the ground station. Following our AOI kml in a Grid in mission planner software.

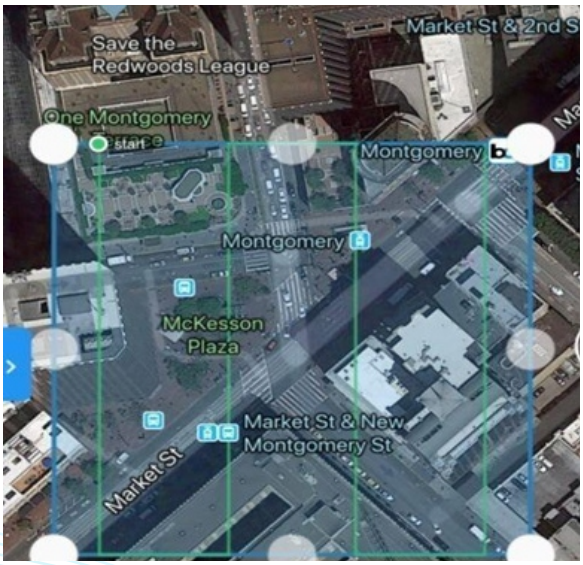


Figure: Drone Planning in Drone Deploy

Key points to consider and keep in mind during field survey

a. Ensure that permission letters are handy and printouts available in person

b. Be aware of the surroundings

c. Fly as per DGCA guidelines to ensure safety

d. Make sure the operator has the right PPE kit

e. Always keep an eye on the drone

f. Keep people a safe distance away from drone take-off and landing site. Once it lands, image data and rover will be downloaded to the computer.

4. Data Processing

4.1. General

The data acquired from the drone survey and the DGPS survey is processed using the technique called Digital Photogrammetry. Entire drone data is stitched together to produce quality outputsof the site. All the outputs can be viewed/downloaded from the vendor data platform.

4.1.1 Initial Processing

Using Photogrammetry software, the tie points and key points have been extracted inthe initial processing by Aerial triangulation and Bundle block adjustment techniques.

4.1.2 Aerial triangulation

I

t is the process of piecing together the block of overlapping aerial images in an objective to determine the position and orientation of each image in the mapping frame.

4.2. Aligning Cameras

Each drone image has a collection of unique features which differentiate it from other images.These are known as key points. Key points from each image are extracted using automatic computer vision algorithms. Extracted features are then searched (in the nearby images) and matching is performed. Using GPS data to search relevant images makes the matching process much faster and accurate. From matched features, fundamental matrix is derived and the relative position between two cameras is estimated. Relative position estimated from the fundamental matrix is generally prone to errors. Bundle block adjustment is used to simultaneously refine the 3D coordinates (Latitude, Longitude, Elevation), orientation parameters (Yaw, Pitch, Roll), and the optical characteristics (distortion parameters) of the camera(s) employed to acquire the images. Bundle block adjustment is a nonlinear iterative optimization process where the objective function is Mean Re-projection Error (MRE) and parameters are the position, orientation and camera distortion coefficients.

4.2.1. Interior Orientation:

It is the transformation of 2D image coordinate system to 3D Camera coordinate system. Parameters of interior orientation come from camera calibration such as lens distortion, principal point, fiducial marks and focal length etc.

4.2.2. Exterior Orientation:

Exterior orientation is establishing relationships between ground and images based on the six parameters (The position of the camera (X,Y,Z) andorientation of the camera (Omega,Phi,Kappa).

4.2.3 Absolute orientation:

Stereo model that was measured from relatively oriented images is transformed into the ground coordinate system.

4.2.4 Tie Point:

A point in a digital image or aerial photograph that represents the same location in an adjacent image or aerial photograph. Tie-points are neededto link images in relative orientation of bundle block adjustment.

4.3. Densing To Build Point Cloud

Depth value is estimated for every pixel in the image using Multi-View Stereo algorithms. Individual depth map of an image is fused together with the depth map of the neighboring image to obtain a 3D point. These points are often called as the dense point cloud. It may evenconsist of greater than 1 crore points for a relatively smaller area. 3D points are triangulated to create Digital Elevation Model (Raster). Every pixel in raster has latitude, longitude and elevation information. Interpolation technique like IDW is used to do 3D point cloud to obtainthe elevation model.

4.4 Orthomosaic & Digital Elevation Models

A digital elevation model (DEM) is a 3D representation of a terrain created from its elevation data. A digital surface model (DSM) represents the earth's surface and includes all objects on it. The digital terrain model (DTM) represents the bare ground surface without any objects likeplants and buildings.

5. Drone Survey Outputs

5.1. General

The major outputs from photogrammetry processing include Orthomosaic for visual representation, Digital Surface Model and Digital Terrain Model for elevation values throughout the site.

5.2. Digital Surface Model

A digital surface model (DSM) represents the earth's surface and includes all objects on it. The DSM is generated using the densified 3D point cloud. Software which you can use to visualise this data: QGIS.

5.3. Orthomosaic

Orthomosaic can be used to measure true distances, because it is an accurate representation ofthe Earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt. Orthorectification step involves creating a visibility or occlusion map with respect to each image. The orthomosaic is generated based on the DSM. Software which you can use to visualise this data: QGIS.

The raster DSM (using Interpolation techniques such as IDW, Triangulation based on the terrain surface) and Ortho-mosaic from the obtained point cloud has been generated.
The resolution of outputs depend on the GSD which further decreased to higher resolution using GIS software.

Figure: Ortho and DSM processed from software

5.4. Digital Terrain Model

The digital terrain model (DTM) represents the bare ground surface without any objects like plants and buildings. The DSM is further processed to remove vegetation and buildings in orderto create a DTM. Software which you can use to visualise this data: QGIS.

5.5. Point Cloud

Point clouds are a collection of points that represent a 3D shape or feature. Each point has its own set of X, Y and Z coordinates. The Point cloud will be generated from extracted Tie Points at point density of 30-50 pointsper sq.m. Point cloud density can be varied based on the GSD and processing setup.

Figure: Point Cloud processed from Images

5.6 Topographic Drawing

From the photogrammetry outputs, the topography of the site is represented as a drawing. Thisdrawing includes quantitative representation of terrain using contours and spot levels. Apart from these, it also represents both natural and man-made features on the site. Software which you can use to visualise this data: AutoCAD.

Point clouds, Orthomosaic can be further processed to extract digitised boundary layers, contours, Digital Terrain Model etc.

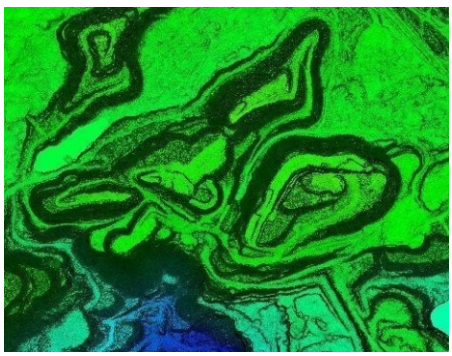


Figure: DTM cleaned and extracted from Point cloud

Software suites currently used after data acquisition are as follows:

1. Pix4D: Image processing to generate 2d Orthomosaic and 3d Point clouds
2. Bentley Microstation: Point Cloud Classification, DTM Generation
3. Global Mapper: ECW conversion, Image Tiling, cropping etc. Quality checks, 3DAnalytics, Digitization
4. ArcGIS: Digitization, Image Tiling
5. AutoCAD Civil/Map3d: Digitization, Volumetric analysis

6. Annexure

6.1. Permits

Before starting the aerial survey, permits are required from District Magistrates in coordination with the concerned ministries. District Magistrate enforces the orders received from ministries to the SP after which SP informs the local police stations and the concerned government officials under his jurisdiction and parallelly District Magistrate informs the same to their Block Development Officer under his jurisdiction.

6.2 Safety Hazards

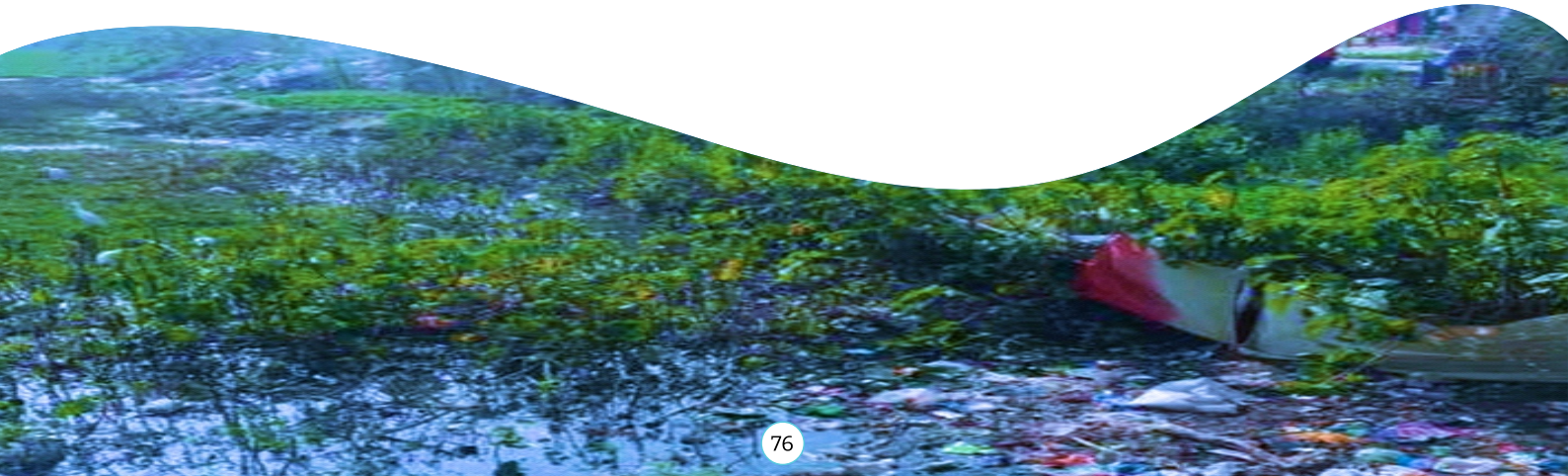
Before starting the aerial survey, we shall identify operational drone safety hazards separated into “active failures” and “latent conditions”, both of which occur or might occur during the flight operations.

1. Loss of control
2. Loss of transmission
3. Collision with buildings, power lines, structures etc.
4. Partial failure or loss of navigation systems
5. Severe weather or climatic events
6. Take-off and landing incidents as undershooting or overrunning

6.3. Points to be considered

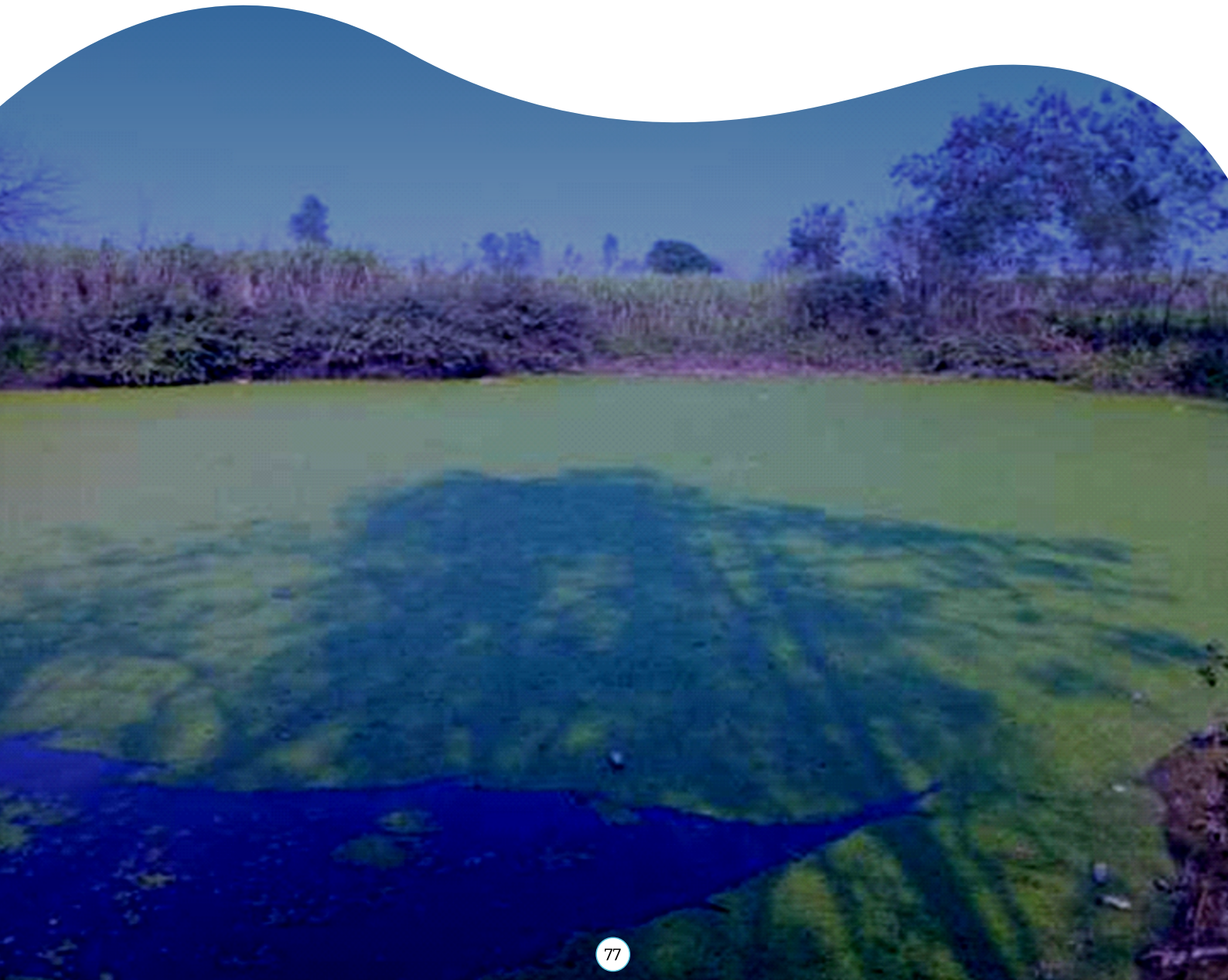
The following must be kept into consideration before deploying the team for aerial survey

1. Travelling in extremely rural areas can be a challenge as the pilot has to go off- road to reach the exact waterbody location.
2. There should be a team of 2 members pilot and a co-pilot with at least one of them fluent with the local language which will help them to communicate with the locals, find out the exact water body and seek help in case of any emergencies.
3. Raw Data Collected by drone is heavy and transferring the same to the data processing team can be a challenge due to poor internet connectivity in the Rural Areas.
4. As drone equipment is bulky, drone operator is required to travel with four-wheel vehicle.



6.3. Points to be considered

Photogrammetry Outputs	Data Provided	
1	Orthomosaic Model Map	Yes/No
2	Digital Surface Model Map	Yes/No
3	Digital terrain Model Map	Yes/No
Topographic Drawings	Data Provided	
1	Topographic Drawing	Yes/No
2	Contour Map	Yes/No
Survey Outcomes	Data Provided	
1	Analysis of Site (Waterbody Area)	Yes/No
2	Feature Map of Waterbody	Yes/No
3	Farmland Details	Yes/No
4	Trees Details	Yes/No



सत्यमेव जयते

National Mission for Clean Ganga

(Registered Society, Under Act 1860)

Ministry of Jal Shakti

Department of Water Resources, River Development & Ganga Rejuvenation

Government of India