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Impact Assessment of Downhill Pipe Conveyor on Ambient Environment

Environmental Management & Policy Research Institute

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Impact Assessment of Downhill Pipe Conveyor on Ambient Environment

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Karnataka Forest Department

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Director General

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List of Abbreviations

AAS	Atomic Absorption Spectrophotometer
AL	Acceptable Limit
APHA	American Public Health Association
AQI	Air Quality Index
Avg	Average
BBC	British Broadcasting Corporation
BDL	Below Detection Limit
BIS	Bureau of Indian Standards
BOD	Biological Oxygen Demand
BS	British Standard
CAD	Computer Aided Design
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CRCA	Cold Rolled Cold Annealed
Db(A)	Decibel in scale A
DHPC	Downhill Pipe Conveyor
DIN	Deutsches Institut für Normung (German Institute for Standardization)
DIP	Digital Interpretation
DO	Dissolved Oxygen
DOS	Department of Space
E	East
EDTA	Ethylenediamine tetraacetic acid
ERDAS	Earth Resources Data Analysis System
FC	Forest Clearance
FCC	False Colour Composite
FRL	Full Reservoir Level
g/cm^3	Gram per centimetre cube
GCPs	Ground Control Points
GIS	Geographical Information System
GM	General Merit
GPS	Global Positioning System
H_2SO_4	Sulphuric Acid
Ha	Hectare
HDPE	High Density Polyethylene
HNO_3	Hydrochloric Acid
HOFF	Head of Forest Force
HSG	Hydrological Soil Group
IEC	Importer - Exporter Code
IIHR	Indian Institute of Horticultural Research

IMHC	International Materials Hadniling Conference
IRS	Indian Remote Sensing
IS	Indian Standards
ISRO	Indian Space Research Organization
JIS	Japanese Industrial Standards
JPC	Japan Pipe Conveyor
KFD	Karnataka Forest Department
Kg/Hec	Kilogram per Hectare
km	Kilometre
L_{10}	Sound level exceeded for 10% of the time
L_{50}	Sound level exceeded for 50% of the time
L_{90}	Sound level exceeded for 90% of the time
LED	Light Emitting Diode
Leq	Equivalent continuous sound level
LISS	Linear Imaging Self Scanning Sensor
L_{max}	Maximum Sound Level
L_{min}	Minimum Sound Level
LU/LC	LandUse/LandCover
m	Metre
Max	Maximum
m/s	Metre per second
µS/cm	Microsiemens per centimetre
$\mu g/m^3$	Microgram per metre cube
meq/100g	Milliequivalent per hundred gram
mg/kg	Milligram per kilogram
mg/L	Milligram per Litre
Min	Minimum
mm	Millimetre
MNG	Mining
MoEF&CC	Ministry of Environment, Forest and Climate Change
MPC	Main Pipe Conveyor
MPN	Most Probable Number
N	North
NAAQS	National Ambient Air Quality Standards
NaOH	Sodium Hydroxide
NASA	National Aeronautics and Space Administration
NH	National Highway
NO_2	Nitrogen Dioxide
NR	No Relaxation
NRSC	National Remote Sensing Application Centre
OBC	Other Backward Class
ºC	Degree Celsius

OFC	Optical Fibre Cable
PAN	Panchromatic Camera
PL	Permissible Limit
PLC	Programmable Logic Control
PM_{10}	Particulate Matter - 10
$PM_{2.5}$	Particulate Matter - 2.5
ppm	Parts Per Million
PRA	Participatory Rural Appraisal
PSK	Pipe Shape Keeping
RSC	Residual Sodium Carbonate
S	South
Sat	Satellite
SC/ST	Scheduled Caste/Scheduled Tribes
SIA	Social Impact Assessment
SIS-DP	Space Based Information Support for Decentralised Planning
SO_2	Sulphur Dioxide
SOI	Survey of India
Sq.km	Square Kilometre
STP	Sewage Treatment Plant
TB	Tunga & Bhadra
TDS	Total Dissolved Solids
TORs	Terms of References
TSS	Total Suspended Solids
TVS	Total Volatile Solids
UTM	Universal Transverse Mercator
VVVF	Variable Voltage Variable Frequency
W	West
WGS	World Geodetic System
WHO	World Health Organisation
WQI	Water Quality Index
WQR	Water Quality Ratings

1 Introduction

1.1 Need for the Project

M/s JSW Steel Limited is transporting Iron ores from various mines to the Vijayanagara steel plant using a closed pipe conveyor system i.e., Main Pipe Conveyor (MPC) since 2019. These pipelines are located downhill, parallel to roadways, and ore from mines is carried through trucks to feed in MPC. However, M/s JSW Steel Limited has planned to transport the ores of different mines through Downhill Pipe Conveyor (DHPC), instead of trucks. The construction of DHPCs involves the diversion of 85.2 ha of forest land which includes 15.9 ha of Sandur Taluk's forest land. Accordingly, M/s JSW Steel Limited has obtained the Stage-I Forest Clearance from the Ministry of Environment, Forest and Climate Change (MoEF&CC) with certain stipulated conditions, out of which **Condition no 10** states that ***"The user agency shall conduct a study, at its cost, involving a reputed Institute on the Impact assessment of Downhill Pipe Conveyor on ambient environment"***. As per the stipulated conditions, a decision was taken by the Karnataka State Forest Department to entrust the task of undertaking *"Impact assessment of Downhill Pipe Conveyor on ambient environment"* in Ballari district to the Environmental Management and Policy Research Institute (EMPRI) for a period of five years (January 2021 to December 2025) in Vide letter reference No. KFD/HOFF/A5-1(MNG)/46/2018-FC, Dated 27/07/2020, copy enclosed as Annexure - I. To carry out the present study, a Memorandum of Understanding (MoU) has been signed between EMPRI and M/s JSW Steel Limited.

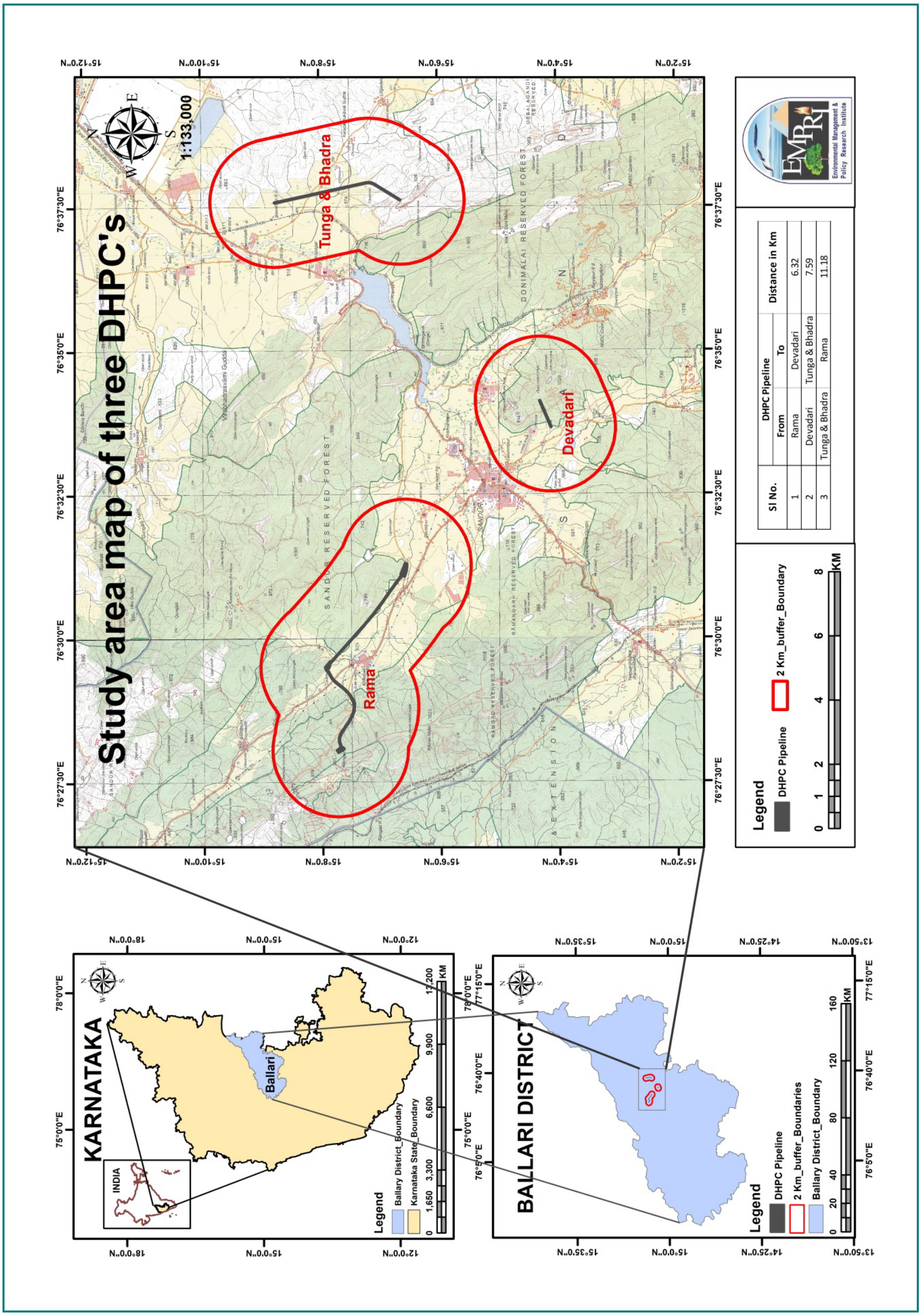
1.2 Study Area Description

The present study comprises three DHPCs that form connectivity from individual mines to Main Pipe Conveyor connecting to the Vijayanagara steel plant. The details of DHPCs are as follows.

1. Devadari Downhill Pipe Conveyor - 933 m (Construction completed)
2. Tunga & Bhadra Downhill Pipe Conveyor – 4,175 m (Under construction)
3. Rama Downhill Pipe Conveyor – 6,452 m (Construction not yet started)

The study area map consisting of all three DHPCs is given in Figure 1.1.

Figure 1.1 Study area map of all three DHPCs



The Terms of References (ToRs) accorded by Karnataka Forest Department is as follows:

I. Inventorisation of water bodies within a one-kilometer radius in the corridor of the DHPC line.

II. Analysis of surface water and groundwater quality (Physico-chemical and bacteriological analysis).

III. Monitoring of ambient air quality in the project area during construction and operation phases of DHPC.

IV. Monitoring of ambient noise levels at suitable intervals and locations in the project area.

V. Analysis of soil quality in the project area at suitable locations.

VI. Meteorological monitoring in the project area (Temperature, rainfall, wind direction, relative humidity and wind speed).

VII. Socio-economic survey (Assess the socio-economic conditions of the people in the project influenced village).

VIII. Land use and land cover pattern analysis would be done by using time-series satellite imageries of the selected study area.

*Monitoring locations within the corridor of the three downhill pipe conveyors i.e. from individual mines to common main/trunk pipe conveyor, connecting to Vijayanagara steel plant, forest area, agricultural land, settlements, industries/schools/colleges/ hospitals (sensitive zones), This monitoring conditions shall remain same for ToR II –V.

The detailed description of downhill piper conveyor system and components of DHPC is given in first year Annual report. In the present report, the analysis and results for second year are presented.

1.3 Study progress

The first year study was conducted from January 2021 to March 2022 and the Annual report was submitted to the Additional Principal Chief Conservator of Forests (FC)/Nodal officer (FCA) Bengaluru, Chief Conservator of Forests Ballari Circle, Deputy Conservator of Forests Ballari Division, and M/s. JSW Steel Limited, Ballari. During the second year the study is carried out from April 2022 to March 2023 and the results are presented for three seasons as follows:

1. Season I – May 2022 to August 2022
2. Season II – September 2022 to December 2022
3. Season III – January 2023 to March 2023

2 Review of Literature

2.1 Pipe conveyor

Kawalec *et al.,* (2020) investigated and compared ore transportation through haul trucks and belt conveyors in Poland (Klodzko, Open-pit mines). Results revealed that belt conveyors transported ore more effectively, and efficiently which reduce gas emissions (5 Tons of carbon dioxide annually), noise level, diesel consumption, transportation cost (95%), and road damage respectively when compared to haul truck systems.

Martins *et al.,* (2020) designed a conveyor belt idler roller using a hybrid topology/parametric optimization. The idler's design is quite important in terms of economics. To minimise the cost of the mining process and enhance idler replacement circumstances, a solid optimization approach for conveyor belt idlers is required. Polymeric materials offer a lot of possibilities for reducing idler weight due to their low density. This study outlines a systematic technique for obtaining the best design for a conveyor belt idler by combining parametric and topological optimization. To develop a surrogate model, the topology optimization approach is applied using different combinations of the shaft's geometric characteristics. After that, an enhanced sequential least-squares quadratic programming approach is used to optimise the surrogate model. The roller used in this study is made of high-density polyethylene.

Fedorko, (2010) reported on the variable pipe conveyor. Conveyor of this type was first operated and constructed by Koch and Tu Company in Finland. The basic principle of this pipe conveyor is to provide a supporting structure on the carrier plates with idlers. Carry plates allow the entire structure to slide freely on a medium incline, allowing for fluent changes in the pipe conveyor track position as well as the filling and dumping locations. The filling and dumping parts of the pipe conveyor are located on the moveable gears and also prove definite limitations of this system of material transport. The Koch and Tu Company developed the conceptual design with help of a Computer-Aided Design (CAD) system and made a proposal and calculation of pipe conveyor parameters. According to the proposed technique, belt transportation can be used in locations and technological operations, where feasible transportation by truck is less and replaced the other modes of transportation, such as truck hauling.

Kesimal, (1997) reported on different types of belt conveyors and provided information about 15 various types of belt conveyors used in mining. In an open-cast mining system, a variety of conveying systems were necessary, uphill conveying at steep angles and downhill conveying, as well as a variety of material sizes suitable for long hauls through challenging terrain. The use of a closed belt conveyor reduces pollution and material spillage and protects materials from rain, dust, wind, and temperature. The conveyor will not work for irregularly sized materials. The maximum conveying angle uphill is 30° and downhill is 18° which is observed during a completely filled conveyor. A closed pipe conveyor system is guided by six idlers which are arranged in hexagonal shape in every frame. Belt conveyor reduces environmental pollution and transportation cost.

Buchanan, (1985) presented at International Materials Handling Conference (IMHC) about the evolution of closed pipe conveyors, sizes of the belt, idlers, and other components of the closed pipe belt conveyor system which is developed and patented by Japan Pipe Conveyor (JPC) Company. JPC with the help of Bridgestone Rubber Company developed a suitable belt for a conveyor system to promote dust free environment, prevent material spillage and increase the limitations of inclination and curve angles. In 1979, JPC installed two pipe conveyors in Japan with a pipe diameter of 300 mm, and length of 20 m and 28 m respectively. Based on these standard sizes, the minimum distance for making a belt into a pipe shape is 25 times the diameter of the pipe conveyor. Spacing between two idlers' frames (Hexagonal shape of idlers arrangements) ranges from 1 to 5 meters. Pipe conveyor diameter varies from 100 to 500 mm diameter, load capacity varies from 36 to 1800 m3/hr, and speed varies from 1 to 4 m/s. Along with all these details, JPC has mentioned belt formation and its strength, idlers sizes, and supporting structure.

2.2 Inventorisation of water bodies

Sekhon *et al.*, (2016) conducted a study on the inventory of water bodies in Hoshiarpur District, Punjab using Remote Sensing and Geographic Information System. During 2014 (Pre and post-monsoon season), the mapping of water bodies was done using IRS LISS III satellite data and a semi-automatic method was followed. Results revealed that the major and minor water bodies present were rivers/streams (6811.5 ha) and small water bodies (2.2 ha) respectively.

Aishwariya *et al*., (2014) studied the delineation of water sources through Remote Sensing (RS) and Geographic Information System (GIS). The objective was to identify various coastal wetlands, map the mangrove patches and to build a wetland database for Udupi district by integrating RS and GIS tools. Wetland mapping and database building for mapping and segregation of wetlands was achieved through supervised classification which uses maximum likelihood algorithm. The Survey of India topographical map surveyed during 1967 was georeferenced and registered with UTM projection & amp; WGS 84 datum, satellite images were coregistered with the top sheet by using Ground Control Points (GCPs) and also the satellite image was subjected to various enhancement techniques like edge enhancement, textural analysis, NDVI and IHS for identification of high waterline, classification and clustering of features. The attribute for each class were drawn for building a GIS database by using this methodology, 14 types of wetlands were identified covering 495 ha of wetland area including estuary, pond, tank, marsh, swamp, rocky marine island, aquatic vegetation, sandy beach, mudflats, mangroves, rivers etc.

Water is an essential resource of livelihood. Water bodies are the places of accumulation of water on the surface of the earth. Earth supports a large and fascinating variety of water bodies. Surface water bodies are essential to water storage units and play an important role in the efficient trapping of huge water quantities from rainfall and runoff events. For irrigation in India, water is drawn from surface water bodies such as major or medium reservoirs, irrigation tanks, etc., (Babu *et al.*, 2013).

Generally, surface water bodies can be grouped into different categories such as oceans, flowing water (rivers and streams), and lakes. Ocean is one huge water source interconnected together.

Flowing water- Rivers and streams are extremely dynamic and the amount of flowing water in any region changes with changes in climate, land use, or vegetation. Lakes are the third general type of water body. Lake is considered to be a large body of natural water, collected in a depression. It differs from a pond or tank due to its larger size, presence of biotic life, and many other ecological factors. Though a reservoir is similar to a lake, it comprises fewer habitats and is mostly man-made (Mission Geography, NASA Educator's Guide).

2.3 Surface and Groundwater

Thotappaiah *et al.*, (2019) studied the groundwater quality of Sandur Taluk, Ballari. A total of fifty locations were selected for groundwater sampling and the study was conducted in all three seasons (summer, rainy, and winter) from March 2016 - February 2017. Results indicated that the pH, Total Dissolved Solids, Calcium, Magnesium, Chloride, Fluoride, Iron, Chromium, Lead, and Cadmium concentration levels were above the Bureau of Indian Standards. In the summer and rainy seasons, groundwater samples showed similar Cations (Calcium>Sodium>Magnesium>Potassium) and Anions (Chloride > Bicarbonate > Sulphate) pattern whereas in the winter season Cations (Calcium > Magnesium > Sodium > Potassium) pattern varied but Anions (Chloride > Bicarbonate > Sulphate) pattern remained same. The groundwater quality deteriorated due to the presence of a higher concentration of Calcium, Magnesium, Fluoride, Iron, etc., and suggested continuous assessment of groundwater quality in Sandur Taluk. The literature is specific to the present study area hence, it was considered.

Goankar *et al.*, (2016) studied the surface water quality of the Sandur schist (medium-grained metamorphic rock) belt, Ballari. A total of 18 surface water samples were collected near the mining belt and the results indicated that the concentration of Iron was found to be in excess in all the sampled surface water bodies as per WHO standards. The haphazard dumping of Iron ore and waste had resulted in erosion/wash-off during the rainy season which in turn increased the Iron content in surface water bodies.

The groundwater quality in the Western part of the Sandur schist belt, Karnataka was assessed (Goankar *et al.*, 2016). During the pre-monsoon season (2012), the study was conducted and results revealed that the Fluoride concentration in 46.1% of collected groundwater samples exceeded the permissible limits (As per IS: 10500 standards for drinking water). This is due to weathering and leaching of fluoride-bearing minerals like fluorite, apatite, and mica from rocks and sediments, etc.

The trace metal contamination in the drinking water of Sandur, Ballari was studied (Thotappaiah *et al.*, 2016). Fifty groundwater samples were collected from March 2015 to April 2016 during the summer, winter, and rainy seasons, and analysed for Iron, Zinc, Nickel, Chromium, Cadmium, and Lead. Results revealed that Iron concentrations in fifty locations were beyond the permissible limits (As per IS: 10500 standards for drinking water) which included Lakshmipura (0.7 ppm), Bhujanganagar (0.8 ppm), Sushilnagar (0.9 ppm), Doulatpura (1.1 ppm), and Bannihatti (0.9 ppm) and it is attributed to the mining activities in the study area. Other trace metals like Zinc, Chromium, Nickel, Cadmium, and Lead were found below the permissible limits.

A study was conducted to understand the water quality status of different villages of Sandur (Kumar *et al.*, 2016). Surface and groundwater samples were collected in August, and September-2012 from different zones (North, South, Central, East, and West) and analysed for pH, Total Dissolved Solids, Total Hardness, Chloride, Fluoride, Nitrate, and Iron. Results indicated a decrease in surface and groundwater quality of the Central part (Narihalla, Sandur, Bhujanganagar, Doulatpura, Sushilnagar, Krishnagar, and Dharmapura Village) followed by the North part (Jaisingpura, Emmihatti, Siddapura, Rajapura, and Radhanagar Village) and South part (Devagiri, Swamyhalli, Agrahara, Obalapura, Devarabudenahalli Village) of Sandur Taluk due to mining activities, usage of toxic chemical (Ammonium Nitrate) for blasting process and deposition of mining waste in water bodies. The literature is specific to the present study area and few of the parameters are similar to the one being analysed in this project too, hence, it was considered.

Pierce *et al.,* (2016) reported urbanization as a major geomorphic process affecting both surface and groundwater systems. Development is increasing inevitably these days; urbanization alters topography and natural vegetation, stream flows and flooding characteristics, temperatures both above and below the land surface, and water quality of surface streams and groundwater. Major physical changes to the groundwater system include changes in water table elevation. Various construction activities and designs affect groundwater if the water table is close to the surface or if deep tunnels or subways are being built, dewatering or depressurization may be required which can lower water tables for considerable periods of time. Urbanization tends to level off the landscape for ease of construction. As impact during construction is important this study was considered and reviewed.

Madhukar and Srikantaswamy, (2013) carried out studies in the industrial area near Bidadi which has the Vrishabhavathi reservoir. This reservoir receives water from the Vrishabhavathi River that flows through Bengaluru city and carries effluent; wastewater from STPs either treated or partially treated. Along with this river carries effluents from various industries that are located on Bangalore to Mysore highway. Studies were carried out for various seasons (post-monsoon, monsoon, and pre-monsoon) in 2011 and 2012 in five locations near Byramangala Lake. Obtained results were compared with drinking water standards given by WHO and ISI. Physico-chemical parameters and 6 heavy metals namely Cadmium, Lead, Chromium, Manganese, Iron, and Zinc were analysed. Results have concluded that COD values were high in the pre-monsoon season, heavy metals were higher than the standards and this was due to industrial effluent from Bidadi industrial area. To understand the heavy metal analysis and its impact, this literature was considered.

Ravikumar *et al.*, (2013) studied to understand the Water Quality Index of two water bodies viz., Sankey tank and Mallathahalli Lake in Bengaluru city. A total of three sampling locations were identified and samples were collected in prior cleaned polyethylene cans for a period of three months. The results were compared with BIS standards –1998. Electrical Conductivity and Sodium Adsorption Ratio values of water were classified for suitability of irrigation purposes. Considering various hardness ranges assigned by WHO, the lake water was found as soft, medium-hard, hard, and very hard. Obtained results were evaluated to know the appropriateness of lake water for domestic and irrigation purposes and results concluded that Sankey tank water quality is better than the Mallathahalli lake sample for domestic and irrigation purposes. But, both the lake water requires a certain degree of treatment for further usage. To understand the sampling procedures and parameters being analysed, this paper was reviewed.

Kumar *et al.,* (2012) assessed the surface and groundwater quality of Sandur. The study was conducted during the monsoon season (June - August 2011). Experimental results showed a higher level of Total Hardness, Magnesium, Nitrate, Fluoride, Sodium, etc., in collected surface water (Toranagallu and Narihalla), groundwater (Ramadurga and Sandur) samples and finally concluded that surface water and groundwater quality have deteriorated due to increased mining activities in Sandur region. The literature is specific to the present study area.

Shukla *et al.*, (2011) conducted studies near the Kanpur industrial area along the right bank of the Ganga River. Twelve water samples were collected and seven major water quality parameters were analysed considering the examination procedure from the APHA manual. Five beneficial classes were considered and WQI limits were prescribed to them. Collected samples were compared to CPCB norms for classification; while for WQI, beneficial classes were considered, and using Bhargava's WQI method, the quality index was calculated. Results revealed that all the samples analysed did not come under the excellent category but they ranged from good to unacceptable. Due to severe contamination, total coliform was detected in the stretch and this resulted in a poor and unacceptable water quality range. This literature gives information on the standard methods to be referred to and the standards to be compared with. Hence, this paper was reviewed.

Suresh *et al.*, (2009) assessed the groundwater quality in and around Ballari city. Samples were collected in the post-monsoon season (The year 2007) and analysed for parameters like Turbidity, pH, Electrical conductivity, Total Hardness, Total Alkalinity, Total Dissolved Solids, Chloride, Carbonate, Bicarbonate, Fluoride, Sulphate, Nitrate, Calcium, Magnesium, Sodium, Potassium, Iron, Zinc, Manganese and Coliform bacteria. Results have shown that the groundwater quality varied significantly in the same area and also in different places of Ballari city. Most of the samples analysed have revealed that the water is not good for domestic use and can be used for irrigation purposes with proper water treatment. The parameters being analysed are similar to the present study hence, to understand the approach and methodology this literature was reviewed.

2.4 Ambient air quality

Chaulya *et al.,* (2019) studied the air quality modelling of Iron ore mines of Saranda (West Singhbhum), Jharkhand during the winter season (December 2015 - February 2016). The air quality was assessed in working, closed, and proposed Iron ore mine areas. Results showed that the Particulate Matter (PM_{10} and $PM_{2.5}$) concentration was above the permissible limit (National Ambient Air Quality Standards) due to Iron ore transportation by trucks. An air quality modelling study revealed that the Iron ore transported through a closed conveyor belt reduced air pollution in the Saranda region.

Shrivastava *et al.,* (2018) assessed the ambient air quality of Khondbond Iron ore mines, Orissa for 24 h at four locations (Near the plant, mining site, weighbridge, and equipment maintenance site) and monitored for Particulate Matter - 10 (PM_{10}), Particulate Matter - 2.5 ($PM_{2.5}$), Sulphur

Dioxide (SO_2) and Nitrogen Dioxide (NO_2). Results revealed that the concentration of all four air pollutants was below permissible limits (National Ambient Air Quality Standards). Higher Particulate Matter-10 (PM_{10}) concentrations were recorded near the plant and mining site due to excess vehicular movement and mining activities. Finally, it was suggested to adopt a conveyor system for the transportation of Iron ore in order to reduce air pollution.

Patel, (2017) studied the environmental impact of Iron ore mining in Ballari, Karnataka. The ambient air quality was monitored at Bannihatti, Bhujanganagar, and Sushilnagar villages of Sandur Taluk for 24 h during pre-monsoon, monsoon, and post-monsoon season (April 2014 - November 2016). Results revealed that Particulate Matter - 10 (PM_{10}), Sulphur Dioxide (SO_2), and Oxides of Nitrogen (NO_X) concentrations of Bannihatti, Bhujanganagar, and Sushilnagar villages were higher in the post-monsoon season followed by pre-monsoon, and monsoon season with concentrations found below the National Ambient Air Quality Standards. Higher concentrations of air pollutants were due to mining activities and vehicular movement, particularly trucks carrying Iron ore.

The ambient air quality of the Iron ore mines of Goa was studied at thirty-four locations for 24 h from January 2011 - December 2012 during summer, post-monsoon, and winter season (Singh and Perwez, 2015). Results showed that Particulate Matter - 10 (PM_{10}) was a major air pollutant with higher concentrations recorded in transportation routes followed by mines and buffer zone. Particulate Matter - 10 (PM_{10}) concentration exceeded but Sulphur Dioxide (SO_2) and Oxides of Nitrogen (NO_X) concentration were within the permissible limit of National Ambient Air Quality Standards.

2.5 Ambient noise

Short term impact study of JSW-MPC on wildlife was carried out by EMPRI (2021). In this study, the impact of LED flood lights, sound frequencies, vibrations, and other impacts on sound revealed that the sounds produced by human-induced landscape changes (traffic), construction, machinery, and maintenance may mask acoustic signals of vocalizing species, potentially motivating individuals to alter the acoustic activity or anthropogenic disturbance can directly and indirectly, affect a variety of behaviours essential to the fitness and survival of species including defence, courtship, mating, and reproduction. The sound parameter of the study area did not assess the direct impact on human health. Pertaining to the faunal study, species may get affected by sound.

Ladanyi, (2016) studied the noise of belt conveyor rollers. As per the studies, the noise generated was mainly due to continuous transportation and the linear nature of the source. The combined operation of noise-generating mechanisms such as roller bearing and its vicinity, contact of roller and belt, the vibration of roller skirt, Air pumping due to movement of the belt, and the vibrations of the conveyor frame act as various sources of noise, Belt and roller interaction with the belt dominates it all. A movable noise barrier directly installed along the track help to attenuate the noise. But the implementation of the same after the installation of the conveyor is expensive. So intervention in the design phase is suggested and also the accurate noise outputs during the design phase need to be estimated for reliable sound propagation. The noise levels of the belt used and new rollers were determined. The applicable standards of this particular study classified three measurement group possibilities as informative, technical, and accurate. Technical accuracy measurement was followed as per Hungarian standard recommendation. An imaginary enclosed surface and sound pressure level were measured simultaneously at each surface portion from which energy and noise output was measured using Hungarian equations. The study concluded that the fundamental cause of noise increase is the wear out of the rollers and an increase in belt velocity has less effect on noise increase.

A belt conveyor constitutes a linear sound source. Sadowski and Fas, (2014) assessed the acoustic work of a coal-transporting conveyor belt that passed through the residential area of Bogatynia in Poland. A mute conveyor system was adopted in the belt and the acoustic effect was assessed and presented in this study. A multilayer sound absorbing and insulating system was constructed in a section of the conveyor belt which reduced the noise by 23 dB(A). The structure of the screen was effective and no additional vibrations were transferred from the conveyor to the ground. The layers included an absorbing plate, three soundproofing plates, an insulation board, an anti-corrosive plate, an insulating rubber layer, etc. Theoretical model analysis was done and presented in analytical and numerical form to present the efficiency of the installed insulating system. It was evident that after the installation of the insulation screen, the noise level reduced in the protected area to below the permissible limits compared to unprotected zones without an insulation screen. Such an insulating layer can be adapted to reduce the noise impact.

Thimmaiah *et al.,* (2011) studied the environmental impact of increased Iron ore production in Ballari, Karnataka. The ambient noise monitoring in Siddapura village was carried out for 24 h using a digital sound level meter during the years 2001 and 2006. The results showed higher noise levels both during the day (60.2 dB(A)) and night time (50.8 dB(A)) in the year 2006 compared to the day (53.3 dB(A)) and night time (46.5 dB(A)) noise levels of the year 2001 due to the increased movement of trucks carrying Iron ore. Since Siddapura village is located close to Rama Iron ore mines the noise level data is useful for the Rama downhill pipe conveyor noise study.

Sadowski, (2005) studied the noise and its minimization in the Iron foundry in Bydgoszcz. A study on the influence of noise on the health condition of employees was undertaken and compared with their work efficiency. Unlike an individual conveyor, an Iron foundry has many sources of noise (including a conveyor). As a cumulative effect, the average noise was found to be 90 to 125 dB(A) often exceeding the permissible limits. The range of noise below 35 dB(A) although harmless agitates the irritation level while noise ranges higher than 35 dB(A), results in low productivity, difficulty in sleeping, and hearing impairment of the employees. 1dB(A) reduction of noise than the average noise range reduces the number of accidents, and injuries by 10%. Considering all these, noise reduction implementation such as soundproofing, and sound absorption materials were used, tested, and found to increase employee productivity by 23%. The study concluded by providing an economical, medical, and ecological significance of noise minimization. Although this study was observed between employees, the impact produced will be similar on every individual health degradation and productivity in the case of downhill pipe conveyor because it passes through many villages in close range.

2.6 Soil Quality

The working plan of Ballari Forest Division (2013-2014 to 2022-2023) Karnataka, mentions the type of soil and minerals present in Sandur and also other taluks of Ballari district. Reddish sandy loam, reddish brown and black soils are present in the Ballari district. The black soil is present over wide stretches of land in Ballari and Hadagali taluks. Reddish sandy loam is present in Sandur Taluk. The reddish brown soils present at the fringes of the hills are due to the decomposition of the rocks. Generally, there is very little organic matter in the soil, which is shallow and supports only poor vegetation. Soil test values conducted in the district have proved that the soil contains a high concentration of soluble salts, which is critical for germination and growth. The available potash is widespread from very low to very high grades. In this context, the need for the application of phosphate fertilizers is to be examined. The black soils contain 68% clay and are rich in lime. Its properties of retaining moisture, cracking deeply in every direction in dry weather, and becoming sticky in wet weather are well known. The red and mixed soils vary widely in composition and quality, ranging from deep ferruginous loams to poor varieties consisting of pebbles. The Ballari district is endowed with rich deposits of minerals of economic importance like Iron and Manganese. The other mineral deposits present include Gold, Copper, Galena, Quartz, and Corundum. High-grade Haematite Iron ore occurs as cresting the synclinal folds of the Dharwar bands, especially the "Sandur synclines" and are considered among the world's richest deposits of Iron ore, the Iron content ranging from 65% to 68%. Kumaraswamy plateau, Donimalai, Ramanamalai, and Ettinahatti-Ubbalagandi region in Sandur North and South ranges are some of the important localities where rich deposits of Haematitic Iron ore are present. The high-grade Haematitic ore reserve in the district is estimated about 1000 to 1,250 Million Tonnes. Ramgad plateau, the Western fringes of Swamimalai and Devagiri plateau in Sandur North and South ranges, and the Eastern slopes of Kallahalli hills in Hospet range are the localities where workable deposits of Manganese ore occur. Indications of ancient workings for Gold are noticed near Ettinahatti in Sandur taluk.

Dash *et al.,* (2016) studied the physico-chemical characteristics of soil near the mining area of Keonjhar, Odisha. Soil samples were collected from Raika, Bansapani, and Kalinga villages and analysed for pH, Conductivity, Organic Carbon, Organic Matter, Nitrogen, Phosphorous, Potassium, and Heavy metals like Zinc, Iron, and Manganese. Results indicated that the Kalinga soil sample had a higher content of Organic Carbon 0.53%, Organic Matter 0.98 %, and Nitrogen 1583.33 Kg/Hec whereas lower content of Organic Carbon 0.32 %, Organic Matter 0.82 %, and Nitrogen 410.5 Kg/Hec was observed in Raika, Bansapani soil sample respectively and concluded that soil characteristics of Raika, Bansapani, and Kalinga villages varied due to mining activities in the area.

Thimmaiah *et al.,* (2011) studied the environmental impact of increased Iron ore production in Ballari, Karnataka. The soil samples were collected in Sushilnagar village (Agricultural land) during 2002 and 2006, and analysed for parameters like pH, Electrical conductivity, Potassium, Chloride, Iron, Organic matter, Sand, Silt, Clay, and Water holding capacity. The results showed increased electrical conductivity (1230 µs/cm) and sand content (99.6%) whereas Organic matter (0.8%) decreased in the year 2006 compared to that of the year 2002 (Electrical conductivity - 625 µs/cm, sand content - 18% and Organic matter - 0.2%). The literature is considered since the location is specific to Rama downhill pipe conveyor study area.

2.7 Meteorology

The effect of precipitation, wind direction, and wind speed on Particulate Matter-10 and Particulate Matter-2.5 concentration in Qinhuangdao City, China was assessed (Liu *et al.*, 2020). The study was carried out in the spring, summer, autumn, and winter seasons from January 2016 to December 2018. During the study period, the precipitation, wind direction, and wind speed data of Qinhuangdao city were collected from Qinhuangdao meteorological station on an hourly basis. Results revealed that moderate rainfall (24.9 mm) with rainfall intensity of more than 5 mm/h, wind speed of 2-4 m/s, and Northern wind direction have decreased the Particulate Matter-10 and Particulate Matter-2.5 concentration with the highest reduction observed in summer followed by spring, autumn and winter seasons. The meteorological parameters and method of data collected in this study are similar to that of the downhill pipe conveyor study.

Silarska *et al.*, (2018) investigated the impact of meteorological conditions on air pollution in Krakow, Poland. Air monitoring was carried out at 7 locations and meteorological data such as rainfall, temperature, relative humidity, and wind speed was collected from the Institute of Meteorology and Water Management from November 2017- to April 2018. Results showed that increased rainfall, temperature, relative humidity, and wind speed, in turn, improved the Air quality of Krakow with a decrease in Particulate Matter-10, Particulate Matter-2.5, Oxide of Nitrogen, and Carbon monoxide concentration. According to this study, meteorological conditions play an important role in the study area and the same criteria are followed for the downhill pipe conveyor study.

Gowda *et al.*, (2015) studied the concentration and distribution of Particulate Matter in the Subbarayanahalli Iron ore mine, Sandur. Ambient air quality was monitored at 8 locations in the summer, rainy, and winter seasons (2014). The meteorological data were collected from Indian Meteorological Department which revealed that the maximum temperature (42ºC) was recorded in summer whereas maximum rainfall (181 mm), relative humidity (95 %), and wind speed (4.57 m/s) were observed in the rainy season. Results showed that the Particulate Matter concentrations at all 8 locations were within the National Ambient Air Quality Standards with higher and lower concentrations recorded in summer and rainy seasons due to varying levels of rainfall, temperature, relative humidity, and wind speed. The meteorological data of this study area is useful for the interpretation of Devadari downhill pipe conveyor meteorological conditions since the Subbarayanahalli Iron ore mine is located close to the Devadari Iron ore mines.

2.8 Socio-economic survey

Pandey and Mishra, (2022) studied the impact of mining activities on the socio-economic conditions of Sandur, Ballari. The study was carried out from July - August 2019 in Ramgad village of Sandur Taluk. A total of thirty-nine households were interviewed using a questionnaire survey. The results revealed that 54.5% of surveyed families were literate. 100% electricity connections, 100% accessibility to drinking water, and 100% unavailability of medical facilities were recorded in surveyed households. The literature is specific to Rama downhill pipe conveyor study area.

Kumar and Basavaraj, (2020) studied the health status of mining labourers in the Ballari district. The study was carried out using primary data like questionnaires, interviews, and case studies and secondary data like past studies, research, etc. The sample size of 500 respondents is randomly selected from an estimated 25,000 mining labours of Ballari. The study stated that the individuals may exhibit physical, mental, and or emotional illness and the behaviour of entire communities may substantially change. The mining area has a high incidence of lung infections, heart problems, and dust inhalation. The generation of dust due to the loading and unloading of ore and vehicular emissions are all a part of transportation pollution. About 95% of industries located in Ballari are predominantly polluting the air. The major polluting industries are found to be mining, Iron ore processing industries, and Steel industries and all these industries use a significant amount of road transportation which also overburdens the infrastructures. The NH13 and state highways are in poor condition due to the continuous movement of heavy vehicles. The health concerns from various sectors of mining are huge as constant loud noise from machines can cause hearing problems including deafness. The vibrating machines can cause damage to nerves and blood circulation and lead to loss of feeling, dangerous infections such as gangrene, and even death at times. The study also finds hiring practices of mining companies; create division among families and communities. This eventually leads to a tear of the social fabric, increased personal stress, and mental health problem throughout the community. Transportation pollution on air will be significantly reduced by adapting pipelines. But like energy, pollution is transferred from air to noise which again causes significant physical and psychological illness in human beings as mentioned in the study.

Centre for social forestry and eco-rehabilitation presented a report on the socio-economic impact of mining and mining policies in the Vindhyan region of Uttar Pradesh (Dubey, 2017). Three districts in the Vindhyan region including Allahabad, Mirzapur, and Sonbhadra where various mining activities occur were chosen as the study area. The socio-economic profile and impact of mining on the soil and vegetation of all these three districts were reported in the study. It was performed by using the Participatory Rural Appraisal tool (PRA) and by questionnaire-based Surveys.

Each district profile was detailed with the geographical description, annual revenue, and major mining regions. The socio-economic details of the districts included gender, marital status, educational status, religion, caste, family structure, income, occupation, dependency on the forest, the impact of mining in forest areas, awareness of forestry programs and mining policies, the dispute in mining, presence of illegal mining, dependency of mining for livelihood, type of dependency on mining, the effect of the closure of mining activity on livelihood, extend of effect on livelihood, health-related problems due to mining, safety precautions adopted in mining, the effect of mining on agriculture, perception regarding restoration program of each district are plotted in this report. The study also revealed the impact of mining on flora and soil characteristics. Impact on flora was compared between the flora of undisturbed (100 m away from the mining site) and disturbed sites (active mining site) of respective mines (stone mine and coal mines). The questionnaire method used in this study is adapted to assessing the socio-economic impact of pipe conveyors in project influenced area of Sandur Taluk so that a clear socio-economic profile can be drawn.

A clean air plan in 2017 was proposed in the Bay area air quality management district. The plan had the first two goals to protect public health and the second to protect the climate. Implementing such a plan denotes compromise in economic activities. The implementation of the plan will benefit the Bay area with air quality, good health, and climate and they were expected to be significant but also affect a wide variety of businesses, households, and land uses. Many emission sources like stationary source, building control, and transportation were identified and their control measure and estimation of the cost was provided. Most of the data used were secondary data extracted from divisions like state employment department and Labour market information, census, etc.

The report discussed larger economic and demographic contexts. The population and annual growth rate of all the regions in the study area from 2005 to 2015 were collected and compared with each for 5 years. The economic context within the region was studied and found that number of private and public sector jobs increased in the region which grew annually by 3.0% between 2010 and 2015. The profession of the population and their individual annual growth were also provided. The economic sector was the sore share of total employment. A statistical description of the industry affecting the region is prepared by analysing the number of establishments, jobs, and payrolls. The sales generated and net profit of the industry was analysed. The cost estimated for control measures was compared with the net profit of individual industries. The evaluation has revealed that there will be adverse impacts on the both private and public sectors. In addition to the direct economic impacts, the health benefits are realized in terms of reduced illness and premature mortality. The climate benefit of 2017 was measured using the social cost of carbon as termed by economists and found both the health and climatic benefits to the tune of billions of dollars. This is similar to the socio-economic impact assessment of the DHPC project as both contribute to the betterment of the environment by reducing air pollution but result at the cost of economic compromise.

Civil engineering projects are significant in developing the economy of the country with adverse socio-economic impact on its immediate environment and have conducted Social Impact Assessment (SIA) in 13 project-influenced towns (3) and villages (10). For any developing project 5 basic methods can be utilized for assessing impacts such as a checklist, interaction matrices, overlay mapping, network, and simulation modeling. For this particular study checklist method was used (Neba and Ngeh, 2009). The same checklist method was followed for assessing the socio-economic impact on the downhill pipe conveyor. SIA was carried out on urban as well as rural inhabitants considering 13 socio-economic variables derived from the issues to be dealt with in the particular pipeline projects. The impact was measured using a continuum scale of 5 to 1 representing positive to negative impact. The results of the 13 variables were interpreted as (1) a total number of surveys and their impact (2) The impact variation with respect to towns and villages as the socioeconomic impact felt was not the same among both the communities (3) Correlation matrix. The Principal Component Analysis (PCA) was used to compress the 13 variables into 3 components which gave a clear picture of impacts.

The study concluded with high medium and low and both positive and negative impacts were observed. In view of positive impacts, local employment, training, and local business development were found to be high. Education project assistance and malaria prevention program were medium and sports facilities, agriculture, and tuberculosis patient assistance were on the lower side. While the negative impact was considered, damage to crops and farmland, abandonment of project facilities, and local attitudes were high. Inequitable distribution of jobs and an inflationary situation were medium. Resettlement of displaced people and damage to cultural and archaeological and religious matters had a low negative impact. The study was well structured in terms of components that are followed in the impact assessment of DHPC on the ambient environment.

Thimmaiah, (2012) conducted a study on the socio-economic and environmental impact studies due to mining in the Ballari-Hospet sector. The socio-economic conditions were assessed with a questionnaire-based survey carried out in 2008. The results revealed that the surveyed villages have accessibility to basic facilities like hospitals, schools, community centers, training centers, etc, which in turn contributed to the upliftment of the living standards of the people. The study also revealed that the surveyed families incurred high expenditure for treatment of the diseases due to environmental pollutants exposure with high health costs recorded in Siddapura and Jaisinghpura villages. The health data of surveyed families revealed that dust allergy and skin allergy are prominent in the study area.

2.9 Land use and Land cover

Patil *et al.,* (2022) studied the LULC pattern of the Narihalla watershed, Sandur taluk. The major land cover considered is built-up area, agricultural area, forest, wasteland, and water bodies. Major features such as tone, texture, shape, and color were spatially interpreted using NRSA classifications and confirmed through ground truth verification. The results showed that the majority of the area present was agricultural land (44%) followed by forest (32.70%), wasteland (18.23%), built-up (3.50%), and water bodies (2.05%) respectively.

Impact of M/s. JSW main pipe conveyor on wildlife was studied by Environmental Management and Policy Research Institute (EMPRI), Bangalore, Karnataka in the year 2021. The Land use and Land cover study was carried out using satellite imageries of the years 2010 and 2021 in the 10 km buffer zone of the main pipe conveyor. Results revealed that the agricultural land had decreased by 260.30 ha and the extent of forest land was reduced by 380.85 ha. This land was converted into a mining/industrial area.

The impact of Yalevsky coal mine (Russia) activities on land use/land cover (LULC) changes on the regional environment and territory were studied (Azeez and Mukhitdinov, 2020). The different land use classes mainly forest, water bodies, road, mining area, agriculture, and grasslands in the study area of Yalevsky coal field area in Prokorvisk city in the Kamerovo region of Russia were identified during the study for a period of 27 years e.g., from the year 1992 to 2019. The changes were detected on a 13 years time interval using Landsat-4 TM, and Landsat-8 OLI by using the maximum likelihood method through ENVI (Environment for Visualizing Images) 5.1 software. In addition post-classification change detection method through ENVI was used to investigate the changes in forest (25.35 km^2), water bodies (0.94 km^2), agriculture to (98.48 km^2), and the road to (10.80 km^2). Increment in the rate of mining area to 100.72 km^2 and grass cover to 34.86 km^2 during the study period. Meanwhile, 90.18 % overall accuracy and (0.87) kappa coefficient for the 1992 classified image, 93.41 % overall accuracy and (0.91) Kappa coefficient for the 2006 classified image, and 88.69 % overall accuracy and (0.85) kappa coefficient for the 2019 classified images were obtained.

The continuous Landsat classification via random forest classifier could be effective in monitoring the long-term dynamics of LULC changes, and provide crucial information and data for the understanding of the driving forces of LULC change, environmental impact assessment, and ecological protection planning in large-scale mining areas (Mi *et al.,* 2019). LU/LC changes in the Godavari coal field area were studied by Grai and Narayana (2018) for a period of 24 years i.e., from 1990 to 2014. The changes were detected on a 5-year time interval by using land sat-5 TM, Landsat-8 OLI, and TIR satellite images along with the human impact on the landscape followed by change analysis and quantification of spatial-temporal dynamics of land use /land cover patterns. The result of this study revealed slight increase in water body, increased from 2.77% - 3.29% from the year 1990-2014. The mining area increased from 0.04% -0.23% in 24 years (1990-2014). On the other hand, the forest area cover has reduced from 36.38% (1990) to 31.67% (2014). The building area and barren land increased from 0.34% to 0.89% and 1.0% to 1.69% in 1990 and 2014 respectively. The study also reported that the agricultural land steadily increased from 59.46% to 62.22% in 24 study years from 1990-2014.

Anchan *et al.,* (2018) conducted studies in Mangaluru taluk to know the land use and land cover change detection through spatial analysis. LULC changes were monitored for the period 1997 – 2017 using GIS techniques. The data was imported to ERDAS and False Color Composite was created. About six major categories were considered namely built-up, agriculture, mixed forest, dense forest, barren land, and water bodies. Each category was further subdivided based on the area. The author concluded that the built area had increased from 6% to 23% while, the forest cover had reduced from 37% to 31% from 1997 to 2017. In the present study, the LULC studies are initiated to understand variation.

Land use and Land cover change in Sandur, Ballari was assessed (Hangaragi, 2016). The Land use and Land cover map of the study area of 2010 and 2014 was prepared using Remote Sensing technology. Results showed that the crop land, forest, and scrub forest present in the year 2010 was 36.20%, 38.76%, and 0.16% but in the year 2014 the crop land (35.55%), forest (34.70%) decreased with an increase in the scrub forest (0.48%), mining (5.10%) and mining waste dump area (0.97%) in Sandur region.

Kumar *et al.,* (2012) studied the Land use/Land cover changes in Sandur, Ballari using Remote Sensing/GIS techniques. ERDAS Imagine 9.1 and Arc GIS 9.2 software was used to prepare the Land use/Land cover maps of the study area during 2000-2010. Land use/Land cover classification results revealed that in the year 2010, the agriculture, urban, and mining/industrial areas were increased to 478.98 Sq. km (38.50%), 13.73 Sq. km (1.10%) and 75.46 Sq. km (6.6%) whereas the forest, wasteland, and water bodies decreased to 445.66 Sq. km (2.93%), 194.23 Sq. km (2.23%) and 30.71 Sq. km (0.56%) respectively compared to the year 2000 due to increased mining activities in Sandur Taluk. Patil et al., (2022) studied the LULC pattern of Narihalla watershed, Sandur taluk. The major land cover considered is built-up area, agricultural area, and forest, wasteland, and water bodies. Major features such as tone, texture, shape, and color were spatial interpreted using NRSA classifications and confirmed through ground truth verification. The results showed that majority of the area present was agricultural land (44%) followed by forest (32.7%), wasteland (18.2%), built-up (3.5%), and water bodies (2.0%) respectively.

In an urban environment, natural and human-induced environmental changes are of concern today because of the deterioration of the environment and human health (Jat *et al.*, 2008). The study of land use/land cover (LU/LC) changes is very important to have proper planning and utilization of natural resources and their management (Asselman and Middelkoop, 1995). Traditional methods for gathering demographic data, censuses, and analysis of environmental samples are not adequate for multi-complex environmental studies (Maktav *et al.*, 2005), since many problems often presented in environmental issues and the great complexity of handling the multidisciplinary data set; we require new technologies like satellite remote sensing and Geographical Information System (GIS). These technologies provide data to study and monitor the dynamics of natural resources for environmental management (Robles and Luna, 2002).

3 Methodology

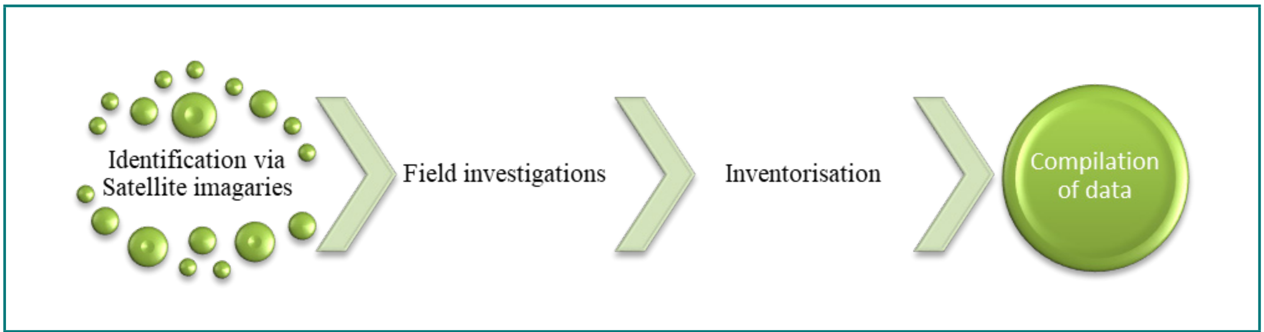
In the present study, several methods and techniques are adopted for sample collection and analysis. Each ToR has an exclusive methodology as follows.

3.1 ToR – I

Inventorisation is a technique to provide quantitative data on water bodies present in an area. Water bodies vary based on their origin, size, and availability of water. Water bodies can either be perennial or seasonal depending upon the water availability and catchment area.

In the present study, the water bodies were identified via satellite imageries in the study area considering a 1km radius buffer zone of each DHPC for surface water monitoring. The identified locations were marked and ground truth verification is done through field visits. The methodology adopted for inventorisation of water bodies is given in Figure 3.1.

Figure 3.1 Methodology for inventorisation of waterbody

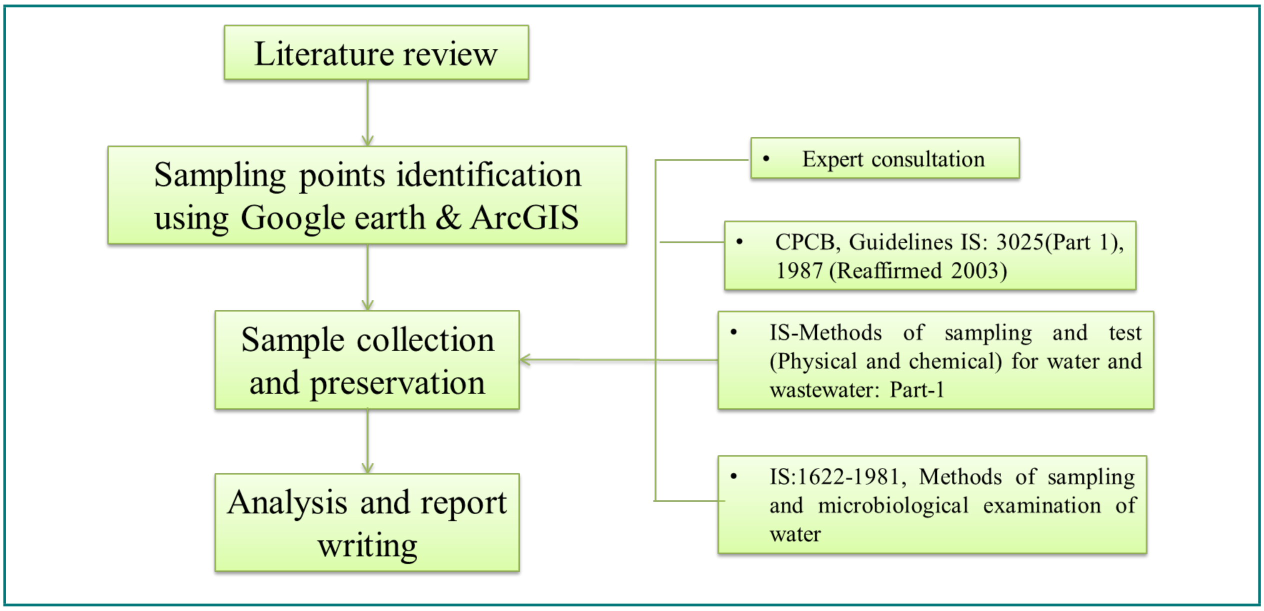


3.2 ToR – II

3.2.1 Surface water

Surface water is any form of water above ground that includes streams, rivers, lakes, reservoirs, wetlands, and creeks, etc., Water quality as a whole is a combination of physical, chemical, and biological characteristics of water. To achieve TOR II various literatures were reviewed, and methods for identification of sampling location and sampling methods were referred to. Along with literatures, subject matter experts were consulted, and CPCB guidelines is followed. The schematic representation for surface water sampling and analysis is given in Figure 3.2.

Figure 3.2 Methodology for surface water sampling



Central Pollution Control Board specifies various sampling methods viz., grab, composite and integrated sampling in their guidelines for water quality monitoring. Out of these three sampling methods, the grab sampling method is adopted in the present study i.e., ***a small representative subset of a larger quantity, concentration, or measurement that is taken at a specific time***. Any effect on the physical, chemical and biological properties of water has a direct impact on the quality of water. Hence, to understand the baseline status of water quality in the study area, surface water samples were collected from 5 lakes considering a 2 km buffer area around each DHPC, considering the composite sampling technique. Surface water samples were collected as per the CPCB guidelines.

- The sampling cans were thoroughly washed using Isopropyl alcohol before sampling.
- Sampling was done wearing all the Personal Protective Equipments.
- Samples were collected using rope, and a bucket and were transported in an ice box with ice pads covered on it.
- Based on the parameters, each sample was collected in 7 containers with individual preservation.
- General samples were collected in 2 L cans.
- Heavy metals and hardness analysis samples were preserved with HNO_3 in 1 L cans.
- COD analysis samples were preserved with H_2SO_4 in 1 L cans.
- Dissolved Oxygen was analyzed onsite for each surface water body.
- An n-Hexane pre-rinsed glass bottle is used to collect a sample for Oil & Grease analysis which was preserved using H_2SO_4.

- Sulphide analysis samples were collected in 1 L can containing Zinc acetate and preserved using NaOH.
- Sterilized brown glass bottles were used for the collection of microbial analysis.

A list of the surface water sampling locations is given in Table 3.1 and the parameters analysed along with the methods followed are provided in Table 3.2.

Table 3.1 List of Surface water sampling locations

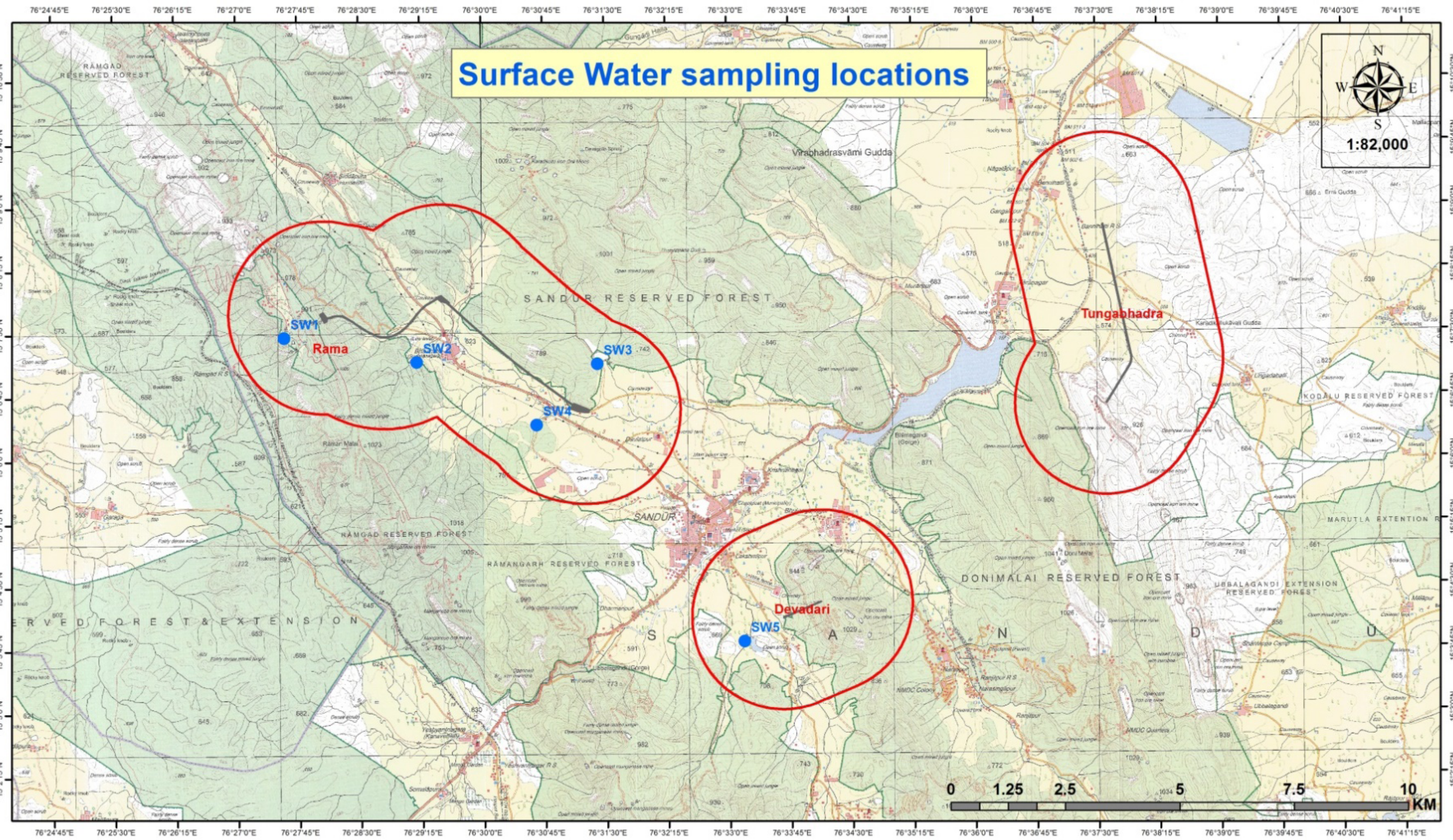
	Study area	Location name	Sample Code	GPS Coordinates
1	Rama DHPC	Ramgad Kunte	SW1	15.1241 N 76.459 E
2		Chinnapankola	SW2	15.119 N 76.48 E
3		Singanakere	SW3	15.118 N 76.523 E
4		Kolifarm Lake	SW4	15.106 N 76.510 E
5	Devadari DHPC	Hulikunte Lake	SW5	15.063 N 76.553 E

Table 3.2 List of Surface water parameters and analysis method

	Parameters	Analysis method
1	pH	Electrometric method
2	Colour	Colorimetric method
3	Odour	Threshold odour test
4	TDS	Gravimetric Method
5	Chloride	Argentometric method
6	Sulphate	Turbidimetric method
7	Fluoride	Spadan’s method
8	Iron	AAS method
9	Boron	Curcumin method
10	Sodium	Flame photometry method
11	Oil & Grease	Liquid-Liquid Separation Gravimetric method
12	TSS	Gravimetric method
13	TVS	Gravimetric method
14	COD	Open reflex principle method
15	BOD	Modified Winkler’s method
16	Phosphate	Stannous Chloride method
17	Sulphide	Iodometric method
18	Residual Sodium Carbonate	Calculation method
19	Total Coliform	Multiple Tube Fermentation Technique

Map showing surface water monitoring locations is given in Figure 3.3.

Figure 3.3 Map representing surface water monitoring locations



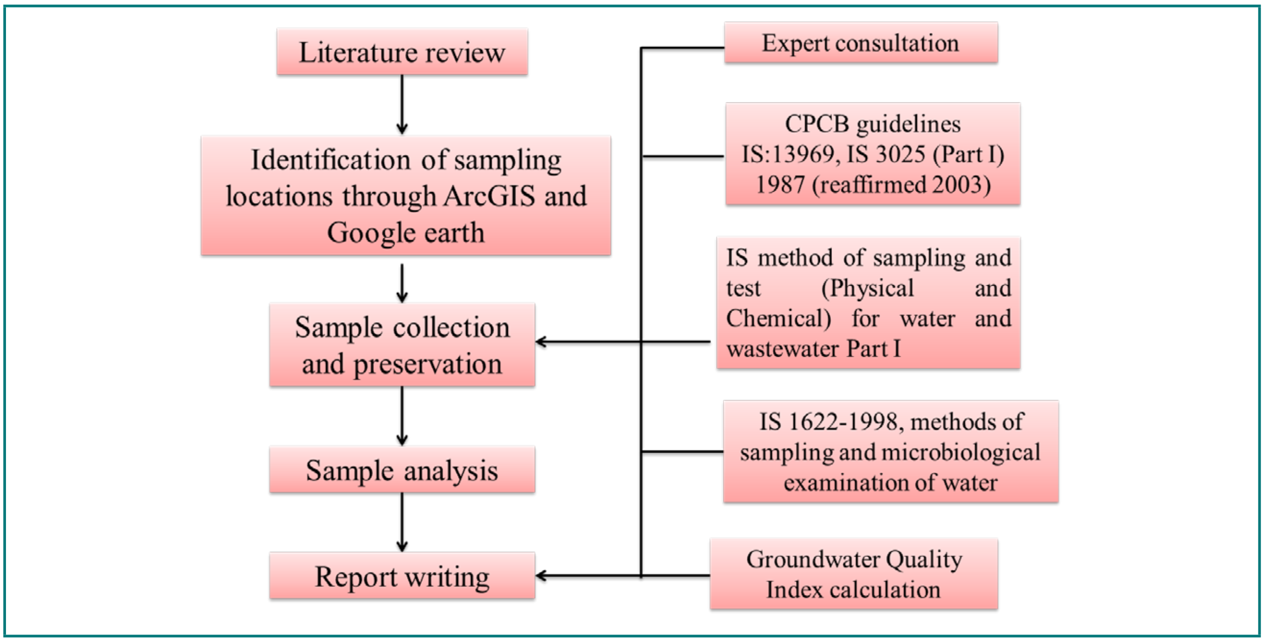
Surface Water samples code	Latitude	Longitude
SW 1	15.124177	76.459699
SW 2	15.119341	76.486649
SW 3	15.11884	76.523412
SW 4	15.106772	76.510963
SW 5	15.063817	76.553024

3.2.2 Groundwater

Groundwater is a significant natural resource, but it is of limited use. This is due to frequent failures in monsoon, undependable surface water, rapid urbanization, and industrialization, creating a major risk to this valuable resource (Ramamoorthy and Rammohan, 2015).

The groundwater sampling and analysis are carried out by reviewing literatures, consulting subject matter experts, and based on CPCB guidelines. The following methodology is adopted for sample collection and analysis. A schematic representation of the same is given in Figure 3.4.

Figure 3.4 Methodology for ground water sampling



Based on IS: 13969 guidelines for a sampling of groundwater and suggestions given by the environment consultant, the samples are collected from existing boreholes. The effect on physical, chemical, and biological properties of water has a direct impact on the quality of water. The containers and preservation of the sample are done as per IS 3025: Part 1 and CPCB guidelines.

- The sampling cans were thoroughly washed using Isopropyl alcohol before sampling.
- Based on the parameters, each sample was collected in 5 containers with individual preservation. Samples were collected from the borehole in the sampling containers.
- General samples were collected in 2 L cans.
- Heavy metals and hardness analysis samples were preserved with HNO_3 in 1 L cans (2 No).
- Cyanide analysis samples were preserved with NaOH in 1 L cans.
- Sterilized brown glass bottles were used for the collection of microbial analysis.
- Sampling was done wearing all the Personal Protective Equipment's.

The list of sampling locations and parameters analysed along with a method of analysis is given in Table 3.4 and Table 3.5 respectively.

Table 3.3 List of Groundwater sampling locations

	Study Area	Location name	GPS coordinates	
			Latitude	Longitude
1	Devadari DHPC	Lakshmipura extension	15.062371 N	76.563097 E
2		Seenibasappa camp - school	15.070578 N	76.556057 E
3		Chikkasandur	15.080062 N	76.550229 E
4		Bhujanganagar school	15.087491N	76.568942 E
5	Rama DHPC	Ramgad - Tayamma temple	15.121533 N	76.462879 E
6		Radhanagar	15.139387 N	76.480325 E
7		Sushilnagar school	15.11921 N	76.497058 E
8		Doulatpura	15.104732 N	76.535338 E
9	Tunga & Bhadra DHPC	Tunga & Bhadra sponge factory	15.146943 N	76.626342 E
10		Tunga & Bhadra road intersect	15.128597 N	76.638335 E
11		Bannihatti transfer point	15.146943 N	76.626342 E
12		Bannihatti school	15.15426 N	76.615926 E

Table 3.4 List of Groundwater parameters and analysis method

	Parameter	Analysis Method
1	pH	Electrometric method
2	Colour	Colorimetric method
3	Odour	Threshold odor test
4	TDS	Gravimetric method
5	Chloride	Argentometric method
6	Sulphate	Turbidimetric method
7	Fluoride	SPADAN's Method
8	Iron	AAS method
9	Boron	Curcumin method
10	Sodium	Flame photometry method
11	Potassium	Flame Photometry method
12	Aluminium	AAS method
13	Copper	AAS method
14	Total Coliform	Multiple Tube Fermentation Technique
15	Turbidity	Nephelometric method
16	Total Hardness	EDTA Titrimetric method
17	Calcium	EDTA Titrimetric method
18	Magnesium	Calculation method
19	Nitrate	Spectro photometric method
20	Zinc	AAS method
21	Cadmium	AAS method
22	Lead	AAS method
23	Manganese	AAS method
24	Faecal Coliform	Multiple Tube Fermentation Technique
25	Mercury	Out Source
26	Total Arsenic	Out Source
27	Aluminium	Out Source
28	Cyanide	Out Source

The Water Quality Index (WQI) for groundwater results is calculated using the arithmetic mean method (Brown *et al.,* 1972). The formula used to calculate the overall WQI is as follows.

Step 1: Calculating the unit weight (W_n) factors for each parameter using following formula

$$W_n = \frac{K}{S_n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where,

$$K = \frac{1}{\sum \frac{1}{S_n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

S_n = Standard desirable value of n[th] parameter

The summation of the unit weight factors all selected parameters, W_n = 1 (unity)

Step 2: Calculation the Sub index (Qn) using following formula

$$Q_n = \frac{[(V_n - V_o)]}{[(S_n - V_o)]} * 100 \quad \ldots\ldots 3$$

Where,

V_n = mean concentration of the n[th] parameters

S_n = Standard desirable value of the n[th] parameters

V_o = Actual values of the parameters in pure water (generally V_0 = 0, for most of the parameters except for pH)

Step 3: By combining step 1 and 2, WQI is calculated as follows

$$Overall\ WQI = \frac{\sum W_n Q_n}{\sum W_n} \quad \ldots\ldots 4$$

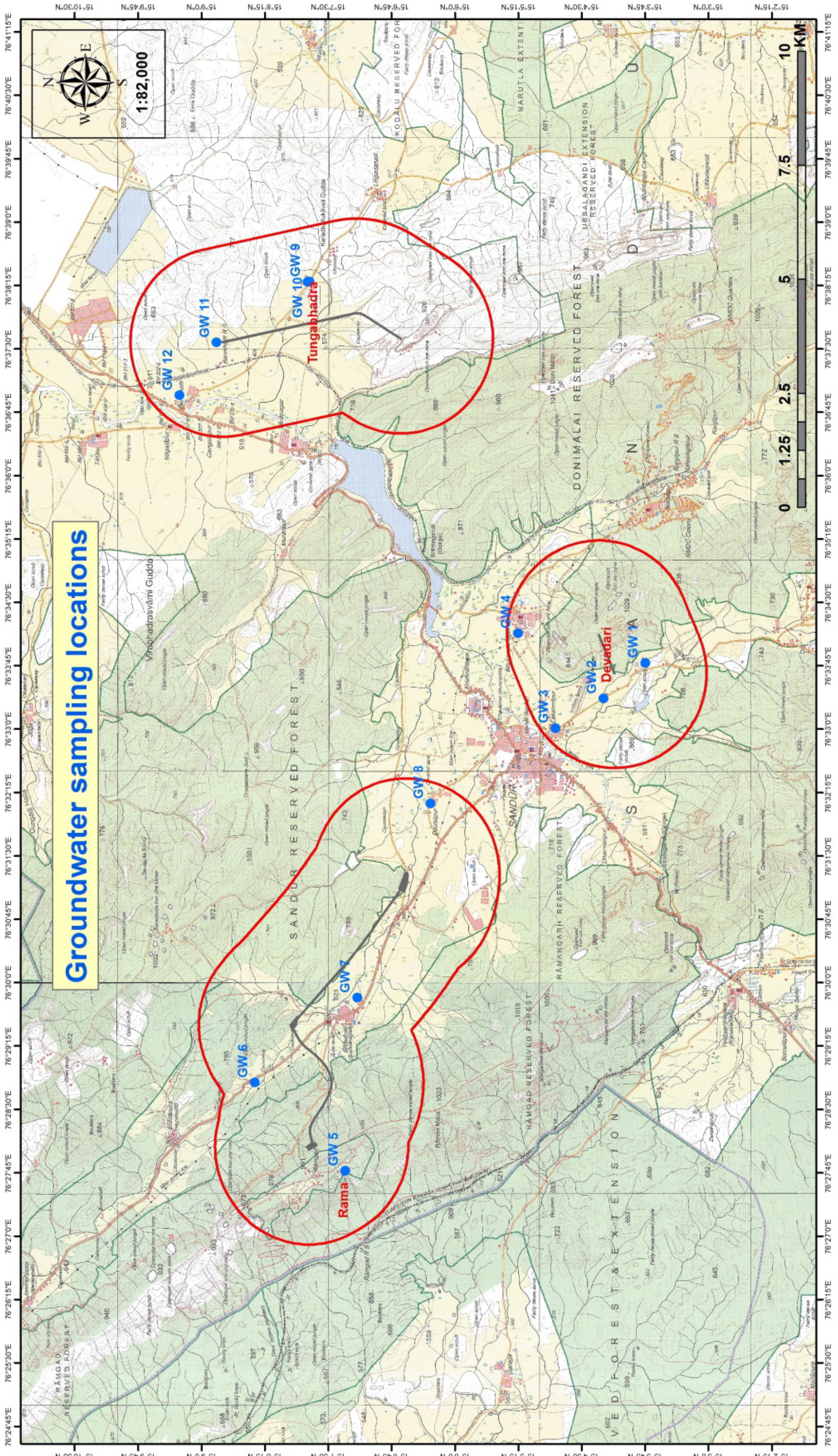
In the present study, the WQI is derived using 16 physico-chemical parameters and its acceptable limit as per IS 10500: 2012. The parameter selection exclusively included Iron and Manganese since the study area is specific to Iron and Manganese mining along with other basic parameters such as pH, Total Dissolved Solids, Turbidity, Chloride, Fluoride, Nitrate, Sodium, Potassium, Sulphate, Boron, Calcium, Magnesium, Total Hardness, and Total Alkalinity. The derived WQI is compared with Water Quality Rating (Seth *et al.,* 2014) mentioned in Table 3.5.

Table 3.5 Water Quality rating as per WQI

WQI	WQR	Grading
0 – 25	Excellent water quality	A
26 – 50	Good water quality	B
51 – 75	Poor water quality	C
76 – 100	Very poor water quality	D
>100	Unsuitable water quality	E

The map showing groundwater sampling locations is given in Figure 3.5.

Figure 3.5 Map representing groundwater monitoring locations



Legend

- Groundwater sampling points
- DHPC Pipeline
- 2kms_buffer_Boundaries

Groundwater samples code	Latitude	Longitude
GW 1	15.062371	76.563097
GW 2	15.070578	76.556057
GW 3	15.080062	76.550229
GW 4	15.087491	76.568942
GW 5	15.121533	76.462879
GW 6	15.139387	76.480325

Groundwater samples code	Latitude	Longitude
GW 7	15.11921	76.497058
GW 8	15.104732	76.535338
GW 9	15.129003	76.638286
GW 10	15.128597	76.638335
GW 11	15.146943	76.626342
GW 12	15.15426	76.615926

3.3 ToR III

Air pollution is a major environmental problem in India that has an impact on human health, agriculture practices, climate, and the ecosystem (Nasir *et al.,* 2016). Major sources of Air pollution are industrial emissions, automobile emissions, construction activities, biomass burning, volcanic eruptions, forest fires, dust, and desert storms that release Particulate Matter - 10 (PM_{10}), Particulate Matter - 2.5 ($PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), etc., (Guttikunda *et al.,* 2014; Sharma *et al.,* 2020; Ganguly *et al.,* 2021).

Particulate Matter is a complex mixture of suspended solid particles and liquid droplets present in the air. PM_{10} is a coarse particle with a diameter of 2.5 to 10 μm. Major constituents of PM_{10} are organic and elemental Carbon, metals like Silicon, Magnesium, and Iron, and ions like Sulphate, Nitrate, Ammonium, etc. The anthropogenic source is the mechanical break-up of larger solid particles, wind-blown dust such as road dust, fly ash, agricultural processes, mining processes, physical processes of crushing, grinding, and abrasion of surfaces, combustion of fossil fuel (Petrol, diesel, coal, heavy fuel oil in thermal power plants, office, factories, automobiles), paper Industry, smelting of metals (Sulphide ores to produce Copper, Lead, and Zinc), petroleum refineries, etc., which cause respiratory illness, visibility impairment, and aggravate existing heart and lung diseases in humans.

$PM_{2.5}$ is a fine particle with a diameter of 2.5 μm or less which is mainly composed of carbonaceous materials (organic and elemental), inorganic compounds (Sulphate, Nitrate, and Ammonium), and trace metal compounds (Iron, Aluminium, Nickel, Copper, Zinc, and Lead). Sources of fine particles are car, truck, bus, and off-road vehicle (e.g., construction equipment, locomotive, etc) exhausts, burning of fuels (such as wood or coal, heating oil), volcanic eruptions, and forest fires. Human health effects include difficulty in breathing, decrease in lung function; aggravated asthma and chronic bronchitis, etc.

NO_2 is a reddish-brown toxic gas with a characteristic sharp odour. Major sources include lightning, forest fires, the bacterial activity of soil as a natural source, vehicles, industrial processes that burn, high-temperature combustion (internal combustion engines, fossil fuel-fired power stations, burning of bio-mass) and fossil fuels are anthropogenic sources. NO_2 irritates the nose and throat and increases respiratory infections in humans.

SO_2 is a colourless, soluble gas with a characteristic pungent smell. Its natural source is volcanic eruptions and anthropogenic sources are the combustion of fossil fuel (coal, heavy fuel oil in thermal power plants, office, factories), paper industry, excavation and distribution of fossil fuels, smelting of metals (Sulphide ores to produce Copper, Lead, and Zinc), petroleum refining and combustion process in diesel, petrol, natural gas driven vehicles. SO_2 in ambient air can also affect human health, particularly in those suffering from asthma and chronic lung diseases with increased respiratory infections (CPCB, 2019).

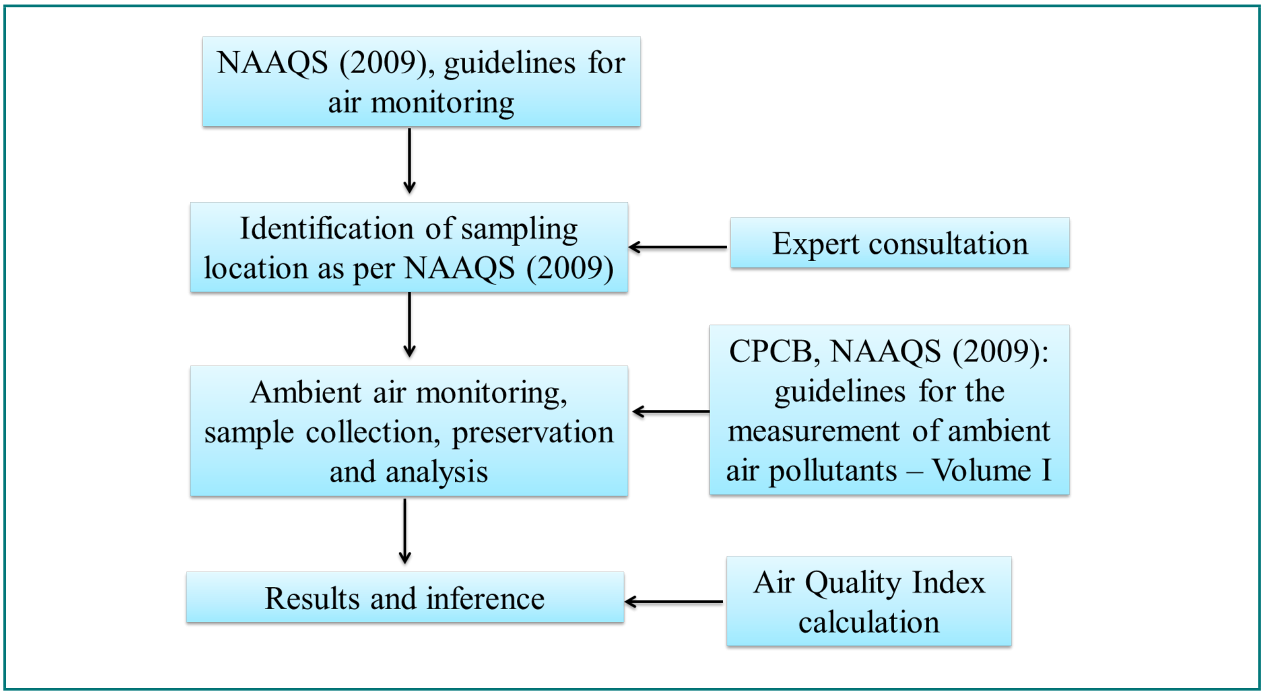
In the present study, ambient air quality is monitored in the construction and operation phases of DHPCs, and results are compared with National Ambient Air Quality Standards (2009) given by CPCB. Based on these guidelines and suggestions given by the subject matter expert, the air monitoring locations and methodology is finalised.

Ambient air quality is assessed considering a 2 km radius of the respective DHPC. Air quality monitoring is carried out in 14 locations comprising forest area, agricultural land, settlement, and sensitive zones (Industries/schools/colleges/hospitals). The criteria followed for the selection of AAQM locations are as follows:

- The stations were selected at a place where interferences are not present.
- Height of the inlet was maintained at 3 ± 0.5 m above the ground level.
- The sampler was kept more than 20 m away from trees.
- There was unrestricted air flow in three of four quadrants.
- The sampling stations selected were away from major pollutants as per the sampling guidelines.
- The monitoring is carried out on two non-consecutive days as per the NAAQ guidelines.

PM_{10}, $PM_{2.5}$, NO_2, and SO_2 is monitored for 24 h as per the Central Pollution Control Board, National Ambient Air Quality Standards (2009) guidelines. PM_{10} and $PM_{2.5}$ concentration was measured by using Respirable Dust Sampler and Fine Particulate Dust Sampler. National Ambient Air Quality Standard (2009) methods were followed for air sampling, and analysis, and the schematic representation of the same is shown in Figure 3.6.

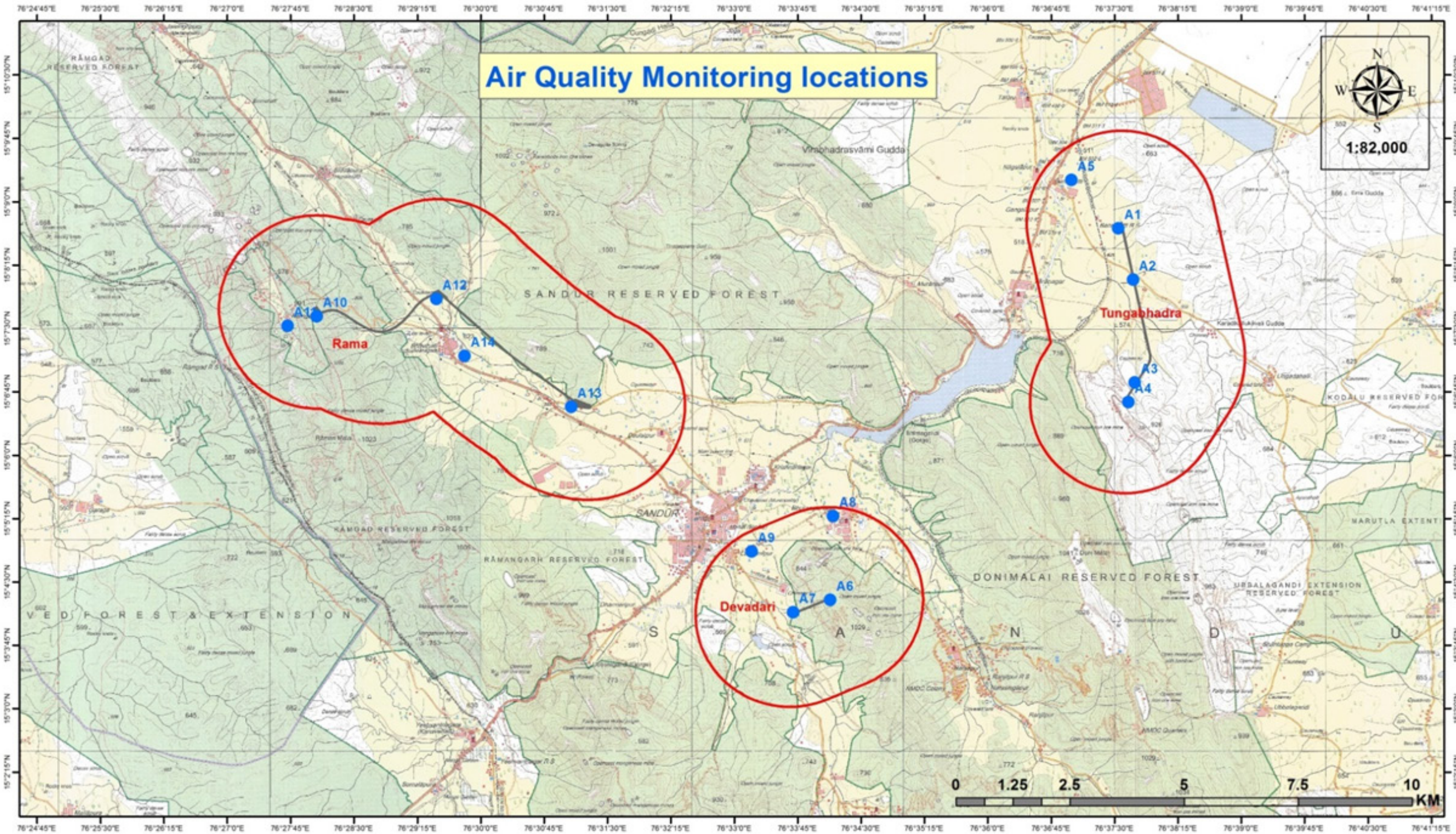
Figure 3.6 Methodology for air monitoring



List of air monitoring locations and paratmeters analysed are given in Table 3.6 and 3.7 respectively.

A map representing the same is given in Figure 3.7.

Figure 3.7 Map showing air monitoring locations



Legend

- Air Quality Monitoring points
- DHPC Pipeline
- 2kms_buffer_Boundaries

Air samples code	Latitude	Longitude	Air samples code	Latitude	Longitude	Air samples code	Latitude	Longitude
A1	15.144724	76.625772	A6	15.071412	76.568949	A11	15.125476	76.461878
A2	15.134631	76.628690	A7	15.068949	76.561622	A12	15.130767	76.491274
A3	15.114329	76.629011	A8	15.087962	76.569517	A13	15.109530	76.517858
A4	15.110418	76.627775	A9	15.080942	76.553465	A14	15.119578	76.496813
A5	15.154289	76.616549	A10	15.127341	76.467659			

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Table 3.6 List of ambient air monitoring locations

	Location	Study area	Latitude	Longitude
1	Bannihatti transfer point	Tunga & Bhadra DHPC	15.144724 N	76.625772 E
2	Road intersect point		15.134631 N	76.628690 E
3	1st pillar point		15.114329 N	76.629011 E
4	Bhadra hopper point		15.110418 N	76.627775 E
5	Bannihatti school		15.154289 N	76.616549 E
6	Devadari hopper point	Devadari DHPC	15.071412 N	76.568949 E
7	Devadari transfer point		15.068949 N	76.561622 E
8	Bhujanganagar school		15.087962 N	76.569517 E
9	Lakshmipura village		15.080942 N	76.553465 E
10	Rama hopper point	Rama DHPC	15.127341 N	76.467659 E
11	Ramgad village		15.125476 N	76.461878 E
12	Transfer point 1 (Sushilnagar)		15.130767 N	76.491274 E
13	Transfer point 2 (Doulatpura)		15.109530 N	76.517858 E
14	Sushilnagar school		15.119578 N	76.496813 E

Table 3.7 List of AAQM parameters and analysis method

Pollutant type		Analysis method	NAAQM standards, 2009
Dust	PM_{10}	Gravimetric	100
	$PM_{2.5}$	Gravimetric	60
Gases	SO_2	Improved West and Geake's	80
	NO_2	Modified Jacob and Honchheiser	80

Based on the results of the analysed parameters, the Air Quality Index (AQI) is calculated using the AQI calculator given by CPCB (Annexure - II) and the air quality is compared with the AQI classification as given in Table 3.8.

Table 3.8 CPCB categories for AQI

AQI range	Category	Color code	Remarks
0 - 50	Good		Minimal Impact
51 - 100	Satisfactory		Minor breathing discomfort to sensitive people
101 - 200	Moderate		Breathing discomfort to the people with lung, heart disease, children and older adults
201 - 300	Poor		Breathing discomfort to people on prolonged exposure
301 - 400	Very poor		Respiratory illness to the people on prolonged exposure
>401	Severe		Respiratory effects even on healthy people

3.4 ToR IV

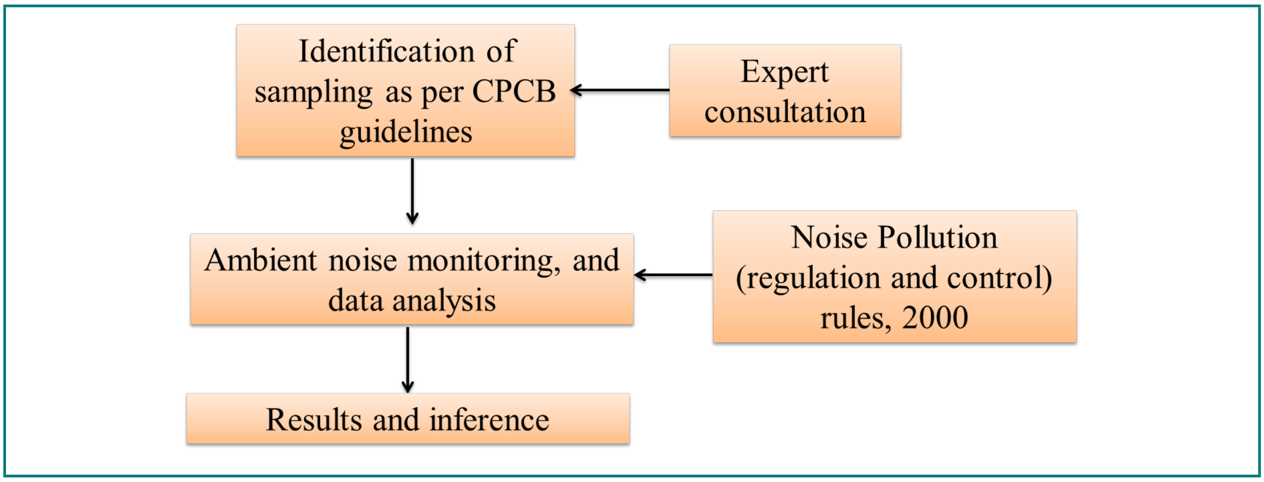
Noise is an unwanted sound, due to its high frequency and amplitude (Mancera *et al.*, 2023). A standard method of recording the ambient noise continuously for 24 h is being followed in the present study as per CPCB regulation and control rules, 2000. Noise level data is collected every second at specific locations along the corridors of DHPC in agricultural land, forest area, settlements, and sensitive zones as per the ToRs.

The methodology followed for the Noise monitoring is as follows:

- A passive recorder was deployed for recording the ambient noise.
- Noise measurements were measured with a Type 1 integrating sound level meter with the free-field microphone which met the accuracy of noise measurement as per IEC 804 (BS 6698) Grade I or Class-I.
- The station is located at the ambient level i.e. away from the direct source, vibration, and obstruction in all the zones.
- A tripod stand was placed above the ground level (1 to 1.5 m) for accurate recording.
- The microphone was placed 1.2 -1.5 m above the ground level in dry conditions with a wind speed of lesser than 5 m/s and the instrument was isolated from strong vibration and shock.
- The monitoring was carried out during day time (06.00 Am to 10:00 Pm) and during the night time (10.00 Pm to 06.00 Am). The exercise was carried out for 6 to 8 h in the said time frame of day and night.
- The data for Leq, L10, L90, L50, L_{max}, and L_{min}, (with 1 sec sampling period at all locations) were collected.
- The sampling is carried out in two non-consecutive days.

The schematic representation of Noise monitoring methodology is given in Figure 3.8.

Figure 3.8 Methodology for noise monitoring



The details of monitoring locations and the geographical coordinates of the same are given in Table 3.9 and 3.10 respectively.

Table 3.9 List of ambient noise monitoring locations

	DHPC name	Location	GPS coordinates	
			Latitude	Longitude
1	Tunga & Bhadra DHPC	Bannihatti transfer point	15.144388 N	76.626068 E
2		Road intersect point	15.133842 N	76.628662 E
3		1st pillar point	15.114648 N	76.628557 E
4		Bhadra hopper point	15.110592 N	76.627449 E
5		Bannihatti school	15.154709 N	76.616523 E
6	Devadari DHPC	Devadari hopper point	15.071857 N	76.569160 E
7		Devadari transfer point	15.068861 N	76.561214 E
8		Bhujanganagar school	15.087640 N	76.569476 E
9		Lakshmipura village	15.080588 N	76.553482 E
10	Rama DHPC	Rama hopper point	15.126951 N	76.467404 E
11		Ramgad village	15.125594 N	76.462117 E
12		Transfer point 1 (Sushilnagar)	15.131120 N	76.491630 E
13		Transfer point 2 (Doulatpura)	15.109148 N	76.517812 E
14		Sushilnagar school	15.119470 N	76.496444 E

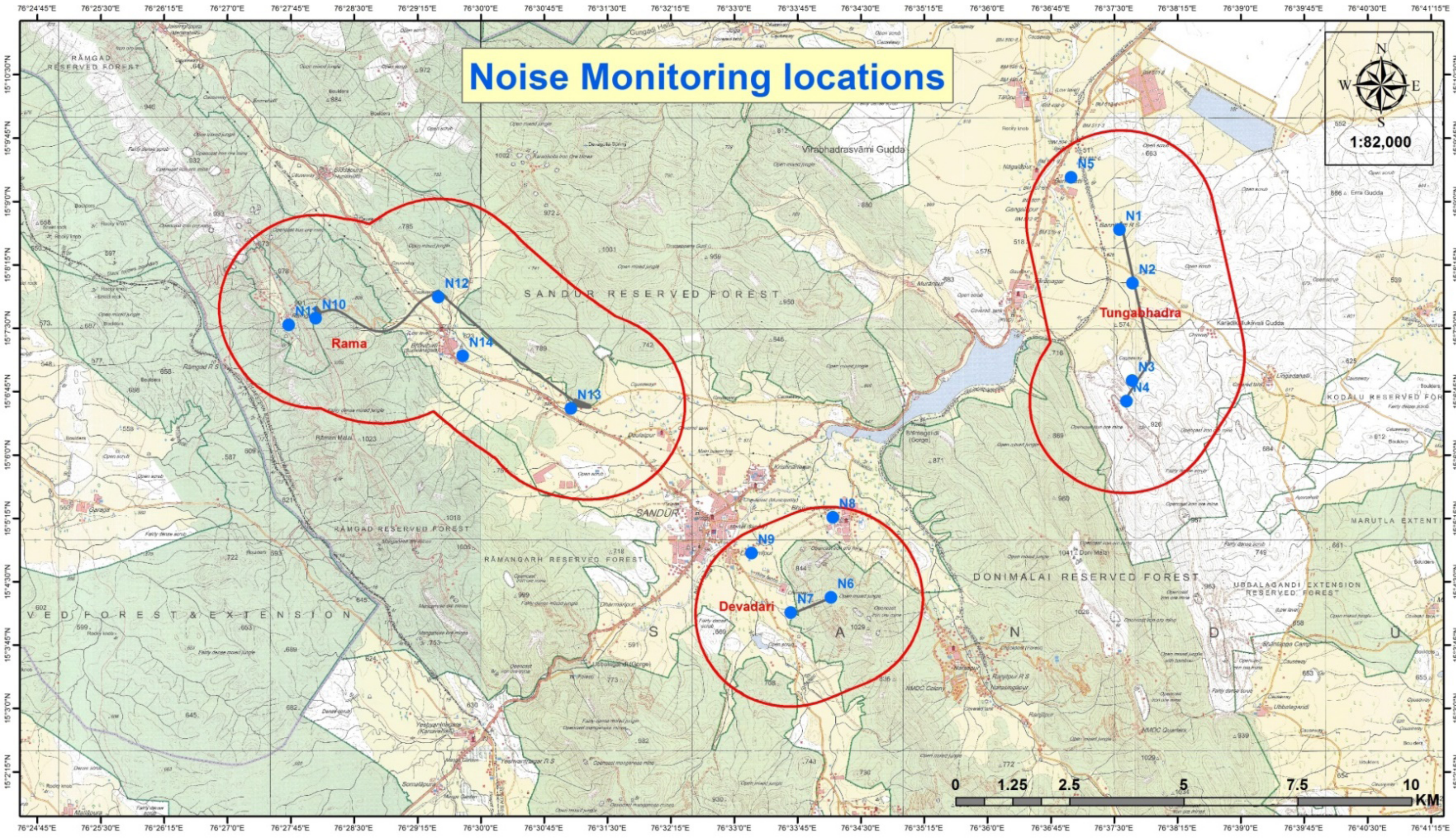
Table 3.10 List of Ambient noise standards and zone

Monitoring frequency	Area code	Category/ Zone	Limit in dB(A)	
			Day*	Night*
24 h	A	Industrial	75	70
	B	Commercial	65	55
	C	Residential	55	45
	D	Silence	50	40

*Day time shall mean from 6.00 Am to 10.00 Pm.
Night time shall mean from 10.00 Pm to 6.00 Am.

The monitoring locations are represented on map and same is depicted in Figure 3.9.

Figure 3.9 Map representing noise monitoring locations



Noise samples code	Latitude	Longitude	Noise samples code	Latitude	Longitude	Noise samples code	Latitude	Longitude
N1	15.144388	76.626068	N6	15.071857	76.569160	N11	15.125594	76.462117
N2	15.133842	76.628662	N7	15.068861	76.561214	N12	15.131120	76.491630
N3	15.114648	76.628557	N8	15.087640	76.569476	N13	15.109148	76.517812
N4	15.110592	76.627449	N9	15.080588	76.553482	N14	15.119470	76.496444
N5	15.154709	76.616523	N10	15.126951	76.467404			

3.5 ToR V

Soil is a mixture of organic matter, minerals, gases, water, and organisms. It is one of the most essential substrate for life on earth, also serving as a reservoir of water and nutrients. Soil sample collection varies based on the purpose and region. An ideal soil sample should represent all characteristics of soil from the sampling area.

In the present study composite soil sampling method is adopted using a soil auger and shovel. The soil samples are collected from identified sampling locations and analysed for the 2 physical and 18 chemical parameters, as per the ToRs. The procedure adopted for soil sampling is as follows:

1. The sampling locations were identified through Google earth and ground truth verification of the same was done.
2. The sampling location was selected considering no physical obstruction and wastes such as plastic, leaves of plants, and others.
3. Samples were collected using a soil auger from 30 cm depth along the four corners and center of the selected area, the collected samples were thoroughly mixed. A pictorial representation of the same is given in Figure 3.10.
4. The mixed samples were split into four quarters and the soil on the opposite quadrants was removed. The soil available in the other two opposite quarters was remixed. The pictorial representation of the same is given in Figure 3.11.
5. The collected samples were analysed.

Figure 3.10 Methodology for sampling

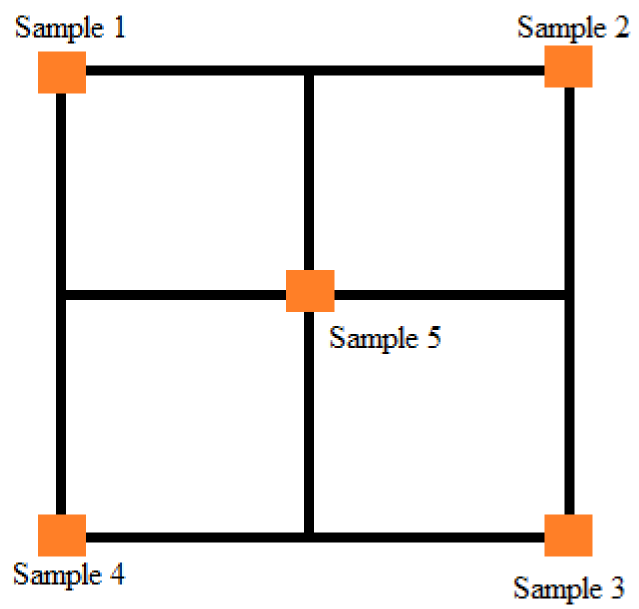
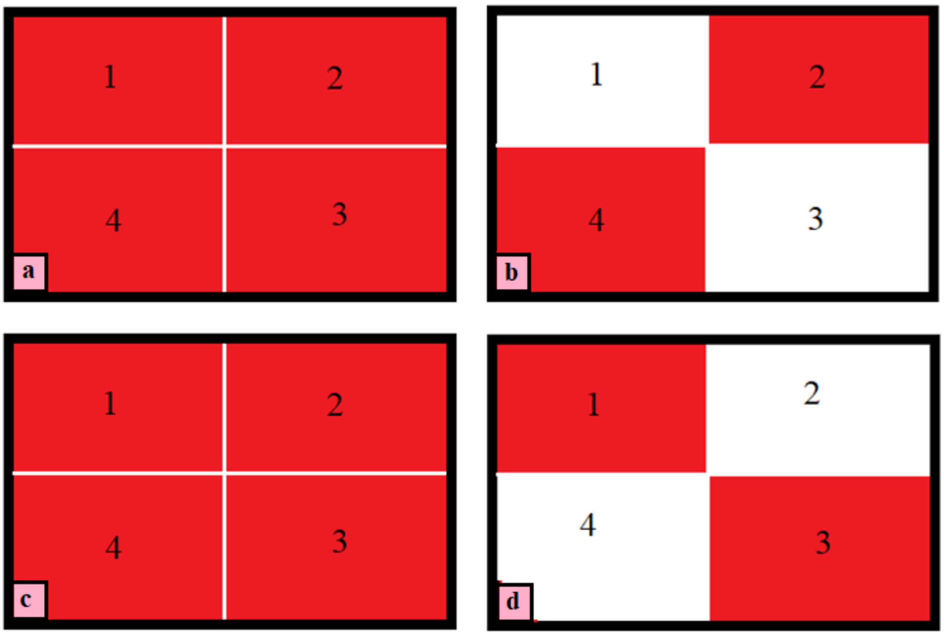


Figure 3.11 Pictorial representation of mixing soil samples



(a) Split into four quarters, (b) Remove soil from two opposite quarters and re-mix, (c) split the soil into four quarters & (d) Remove soil from other two opposite quarters.

The details of sampling locations and parameters being analysed are given in Table 3.11 and 3.12 respectively.

Table 3.11 List of soil sampling locations

	Study Area	Location name	GPS coordinates	
			Latitude	Longitude
1	Devadari DHPC	Lakshmipura extension	15.062371 N	76.563097 E
2		Seenibasappa camp - school	15.070578 N	76.556057 E
3		Chikkasandur	15.080062 N	76.550229 E
4		Bhujanganagar school	15.087491 N	76.568942 E
5	Rama DHPC	Ramgad - Tayamma temple	15.121533 N	76.462879 E
6		Radhanagar	15.139387 N	76.480325 E
7		Sushilnagar school	15.11921 N	76.497058 E
8		Doulatpura	15.104732 N	76.535338 E
9	Tunga & Bhadra DHPC	Tunga & Bhadra sponge factory	15.146943 N	76.626342 E
10		Tunga & Bhadra road intersect	15.128597 N	76.638335 E
11		Bannihatti transfer point	15.146943 N	76.626342 E
12		Bannihatti school	15.15426 N	76.615926 E

Table 3.12 List of Soil parameters and analysis method

	Parameters	Analysis method
1	pH	Electrometric method
2	EC	Conductivity method
3	Sodium	Flame Photometric method
4	Phosphate	Out Source
5	Potassium	Flame Photometer method
6	Calcium	EDTA Titrimetric method
7	Magnesium	EDTA Titrimetric method
8	Chloride	Argentometric method
9	Nitrate	Out Source
10	Sulphate	Out Source
11	Water holding capacity	Calculation method
12	Sodium Adsorption Ratio	Calculation method
13	Exchangeable Sodium Percentage	Calculation method
14	Sand/Silt/Clay	Sedimentation method
15	Organic Carbon	Walkey & Black method
16	Organic Matter	Calculation method
17	Bulk Density	Calculation method
18	Porosity	Calculation method

Hydrological Soil Group (HSG) classification used to identify the soil type in the study area is given in Table 3.13.

Table 3.13 Hydrological Soil Group

HSG	Soil Texture	Sand	Clay
A	Sand, loamy sand or sandy loam	>90 %	40 %
B	Silt or loam	50-90 %	10-20 %
C	Sandy clay loam	<50 %	20-40 %
D	Clay loam, silt clay loam, sandy clay, silty clay or clay	<50 %	>40 %

The map representing the soil sampling locations is given in Figure 3.12.

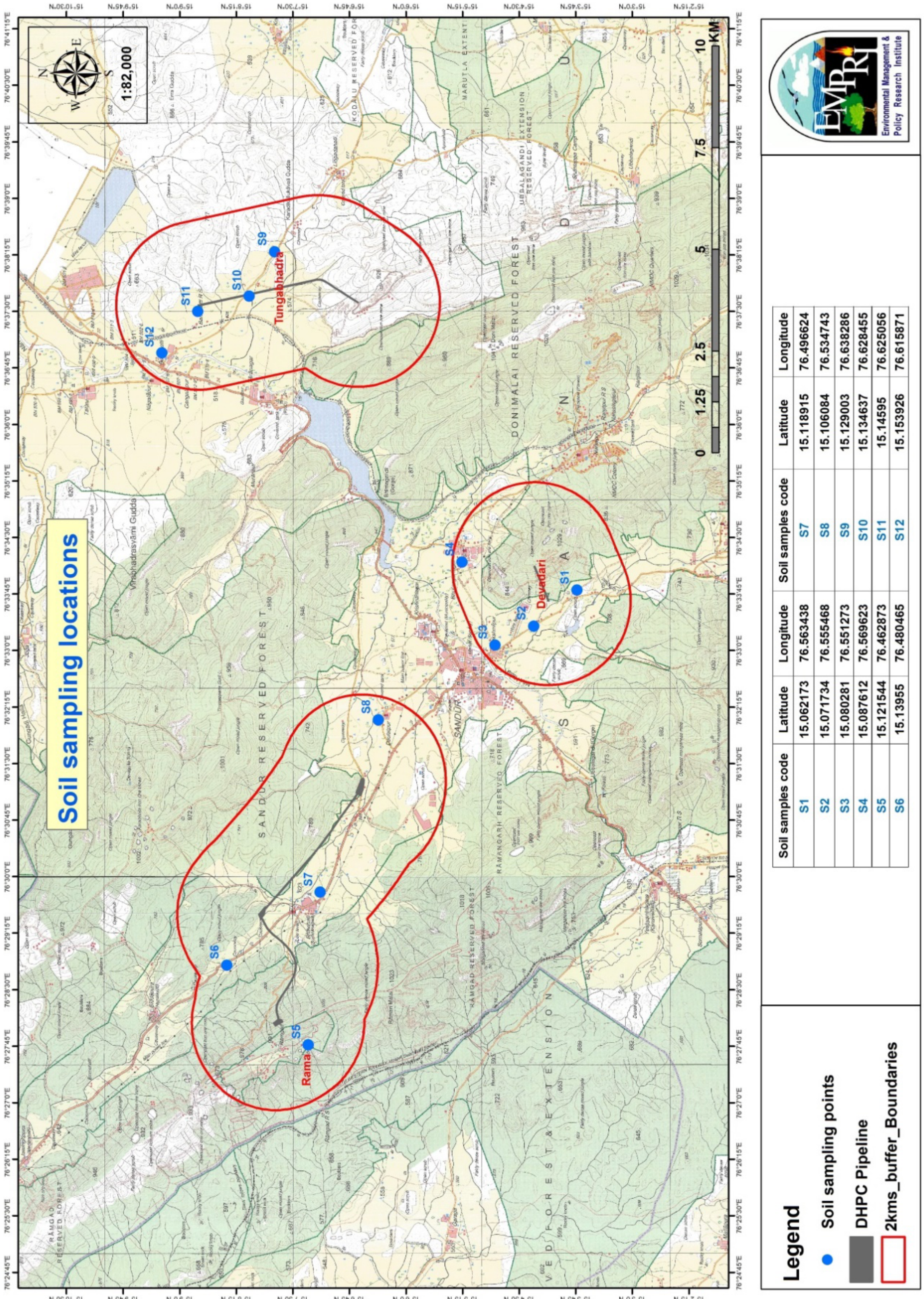


Figure 3.12 Map representing soil sampling locations

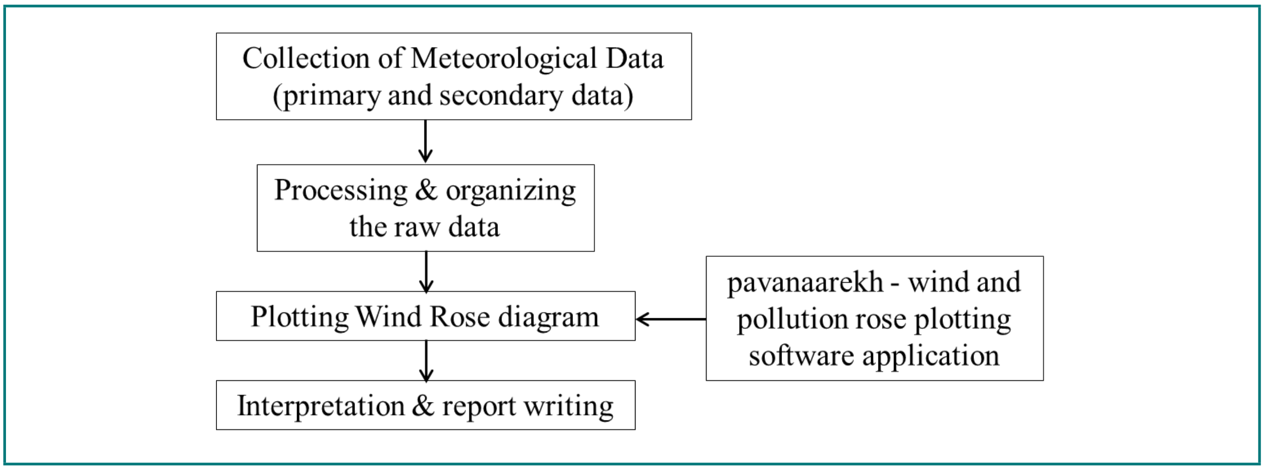
3.6 ToR VI

Meteorology is one of the oldest observational sciences in human history and perhaps the most relevant to a broad segment of society. Meteorology is a science that deals with motion and the phenomena of the atmosphere with a view to both forecasting weather and explaining the processes involved. It deals largely with the status of the atmosphere over a short period and utilizes physical principles to attain its goal.

The concentration of air pollutants in ambient air is governed by meteorological parameters such as atmospheric wind speed, wind direction, relative humidity, and temperature. Air pollutants are being let out into the atmosphere from a variety of sources, and the concentration of pollutants in the ambient air depends not only on the quantities that are emitted but also on the ability of the atmosphere, either to absorb or disperse these pollutants. Understanding the behaviour of meteorological parameters in the planetary boundary layer is important because the atmosphere is the medium in which air pollutants are transported away from the source, which is governed by meteorological parameters such as atmospheric wind speed, wind direction, and temperature.

In the present study, meteorological data like temperature, rainfall, relative humidity, wind speed, and wind direction were collected from respective stations installed by EMPRI, Bangalore in the study area. The methodology adopted for the present study is represented in the schematic diagram and the same is represented in Figure 3.13.

Figure 3.13 Methodology for meteorological data analysis



The details of meteorological stations installed by EMPRI are given in Table 3.14.

Table 3.14 Details of meteorological stations installed by EMPRI

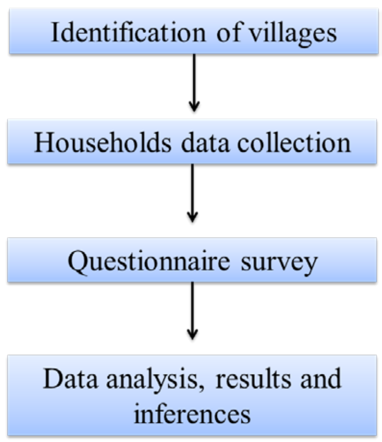
	Station name	Latitude	Longitude	Location
1	WS-JSW Rama mines-Ramgad	15.124255˚N	76.467424˚E	Rama Iron ore mines, Ramgad village, Sandur Taluk, Ballari District
2	WS-Tunga mines	15.10275936˚N	76.63253784˚E	Tunga Iron ore mines, Sandur Taluk, Ballari District
3	WS-Devadari mines	15.1765785˚N	76.6233978˚E	Devadari Iron ore mines, Sandur Taluk, Ballari District

3.7 ToR VII

A socio-economic survey is an important tool that determines the socio-economic conditions of an area/region based on education, occupation, population, income, health status, etc (Priyanka and Megha, 2018 & Islam and Mustaquim, 2014).

In the present study, the socio-economic survey is carried out, to understand the impacts of the downhill pipe conveyor, during the construction and operation phase, on socio-economic conditions of the people residing in the nearby villages of the project area. The villages located within a 5 km area on either side of Devadari, Tunga & Bhadra, and Rama DHPC study area were identified through satellite imageries. Details of the village population and the number of households were collected through the Census of 2011 data (https:www.censusindia.gov.in) and the survey was carried out considering 10% of the total population as per expert advice. The survey questionnaire is enclosed as Annexure - III. A schematic representation of the methodology is given in Figure 3.14.

Figure 3.14 Methodology for Socio-economic survey



3.8 ToR VIII

In the present study remote sensing and GIS tools are used to analyse the Land Use/Land Cover (LU/LC) changes for the year 2012, 2018, 2021 and 2022. The satellite imageries are procured from National Remote Sensing Centre (NRSC) for the year 2022 and interpretation of the imageries are done to analyse the change detection. Arc GIS 10.3.1 software is used for the interpretation and ERDAS Imagine software is used for image processing.

The study area is spread across 76° 22′ 24.636′′E to 76° 43′ 30.141′′E and 14° 58′ 39.149′′N 15°14′ 12.259′′N of Sandur taluk, Ballari district and Hospet taluk of Vijayanagara district. The study area consists of 10 kms and 2kms buffer zone on either side of the DHPC. The GIS layers extracted from 2011 District Census published handbook with taluk and village maps show that the 10kms buffer zone encompasses of 97 village boundaries (Ballari -76 Villages and Vijayanagara -26 Villages) intersecting the buffer zone frontier. It is to be noted that some villages fall completely inside the buffer boundary and some village boundaries are having only a negligible area inside the buffer zone margin. Further, some of the intersecting village boundaries have settlements within the buffer zone and other village boundaries have settlements away from the buffer zone. The study area map of DHPC with 2kms and 10kms buffer is shown in the Figure 3.15.

Datasets - The LU/LC change detection studies are basically carried out by applying various remote sensing techniques using different spatial-temporal imageries. To execute the tasks of image classification and processing there are various Digital Interpretation (DIP) techniques. In the current study Visual Interpretation technique is practiced to obtain the LU/LC patterns of the study area. In addition to the basic satellite imagery, other reference base data sets are necessary. For a comprehensive study of Land use/Land cover change detection studies the following data products are used.

1. Toposheets
2. Satellite imageries
3. Google earth reference
4. PS based data from Ground truth verification

3.8.1 Toposheets

The Survey of India toposheets (SoI) are used as base maps for referring details related to settlements, administrative boundaries, reservoir FRL limits, etc. The toposheets are use for geo-referencing the satellite imagery and identification of existing features such as forests, scrub regions, sheet rock areas and so on. The lists of toposheets used in the present study are given in the Table 3.15 and figure representing toposheet grid is given in Figure 3.16.

Table 3.15 List of toposheets

	Toposheet no.
1	57A08
2	57A12
3	57B09

Figure 3.15 Study area map of DHPCs with 2kms and 10kms buffer

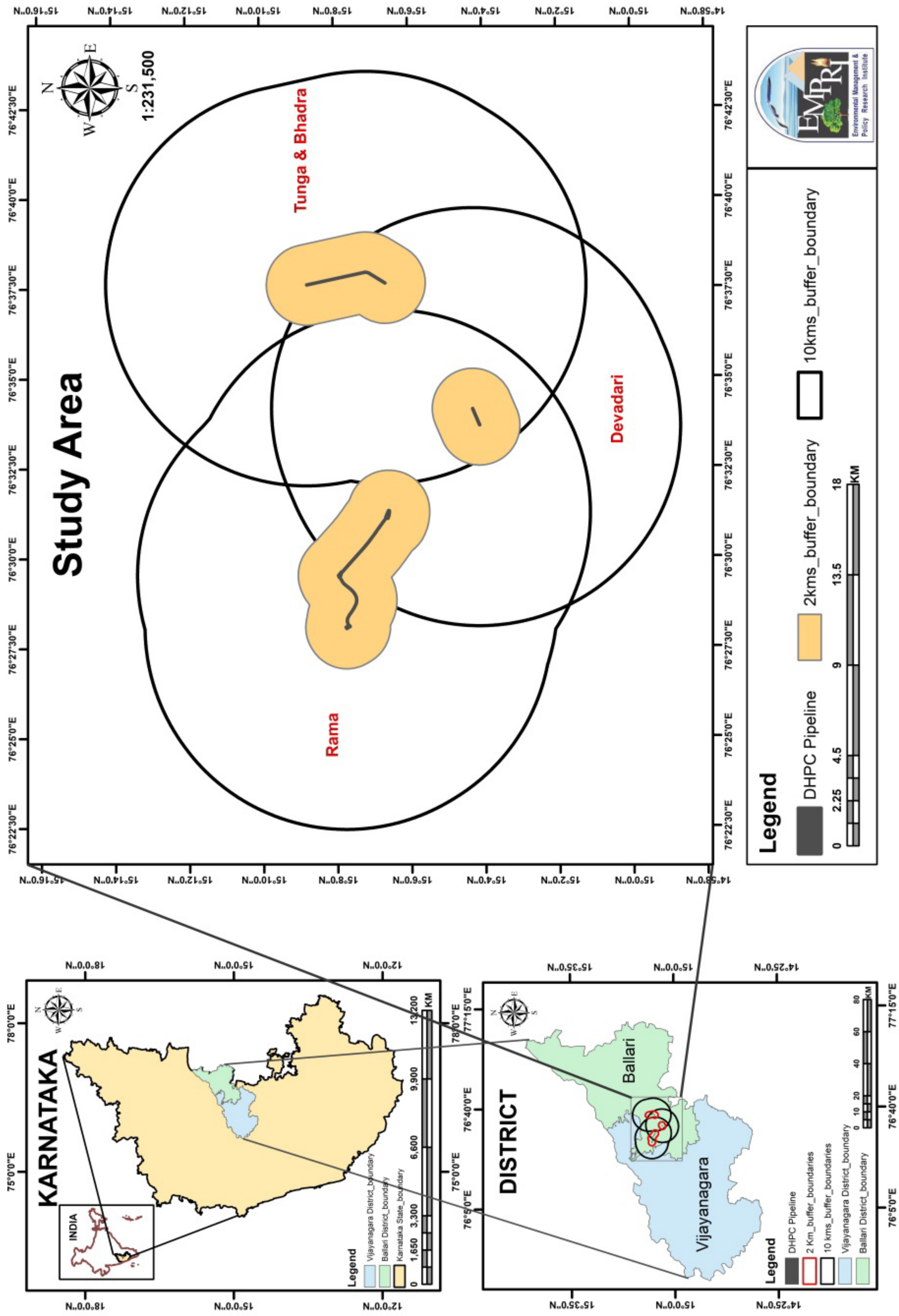
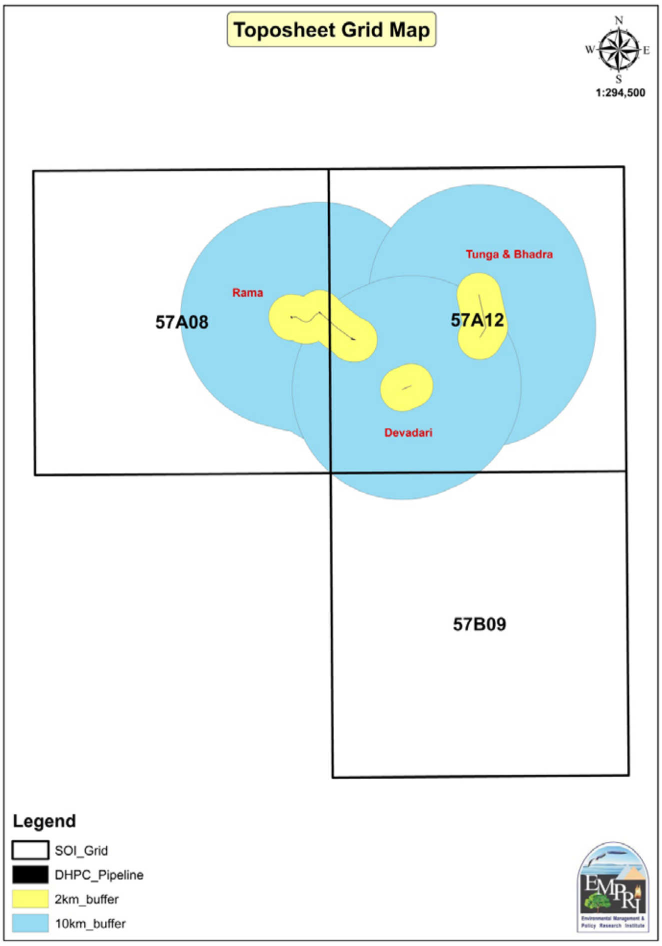


Figure 3.16 Toposheet grid map



3.8.2 Satellite imagery

The Satellite imagery is the major data set to delineate the LU/LC classification for the desired scale depending upon the resolution of the imagery. For the current study satellite imageries of the years 2012 & 2022, 2018 & 2022 and 2021 & 2022 have been used to detect the changes in LU/LC features in the study area. The image classification requires cloud free imageries for clear visual interpretations, hence imageries during winter season (December-March) is used. LISS-IV imagery from Resource Sat-2 satellite of winter season is used. Image pre-processing operations such as layer stacking, geo-referencing, ortho-rectification, resolution merge have been done on the imageries to achieve high resolution accuracy of 5.0 meters. Details of spectral bands of Satellite imagery considered for the study area are given in Table 3.16.

Table 3.16 Spectral band of satellite imagery

	Sensor	LISS IV
1	Band 1	0.52 – 0.59 µm
2	Band 2	0.62 – 0.68 µm
3	Band 3	0.76 – 0.86 µm

The scale for the data prepared is calcualted using the following formulae

$$0.25\ mm\ \times scale\ = resolution\ of\ imager\ \ldots\ldots 5$$

$$\therefore Scale\ = \frac{resolution\ of\ imagery}{0.25\ mm}\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

$$Scale\ = \frac{5.0\ m}{0.25\ mm} = 20{,}000\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 7$$

Thus, the scale of the LU/LC classes obtained would be on a scale of 1:20,000.

3.8.3 Google Earth Application

Google Earth is Geographical information program which contain virtual globe as well as maps of entire globe. The maps are resultant of superimposition of satellite imagery, aerial photography and Geographical information system on to a 3D platform. Google Earth is used as base map in case of satellite image classification and also can be used for verifying sample image classification data. It has option to view historical imagery acquired at different dates or years which can be used for change detection purpose.

3.8.4 GPS based data from ground-truth verification

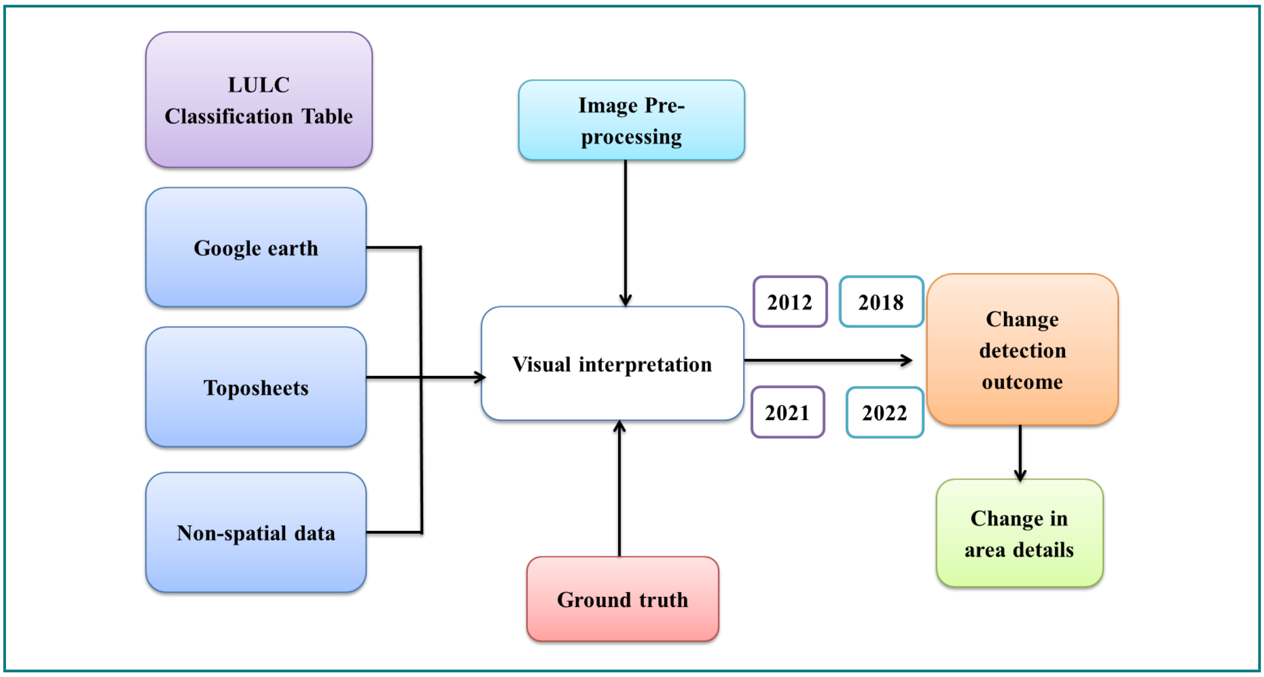
Ground truth / field verification is an important component in mapping and its validation exercise. Utmost care and planning is taken while collecting ground data and its verification. To facilitate a good ground truth the following steps were followed:

1. Identification and listing of all the doubtful areas for ground verification and all such areas with respect to toposheet were referred to know their geographical location and accessibility on the ground.
2. Field traverse plan was prepared to cover maximum doubtful areas in the field. It is also ensured that each traverse covers as many Land Use / Land Cover classes as possible, apart from the doubtful areas.
3. The number of points to be covered for each category is pre-determined before field visits. These observations are required both for quality checking as well as accuracy estimation, in addition to use in interpretation.

The field verification for the doubtful areas was carried out using GPS instrument and the observations were reported and incorporated while preparing the LU/LC classification.

LU/LC is one of the basic information required for assessing the status of any region. The inventories of various LU/LC patterns which were present earlier and are currently present will aid in the assertion of changes that have occurred over time. This is the primary step for identifying, planning, and management of the areas which are to be protected as eco-sensitive zones. In order to create LU/LC layer in GIS compatible manner and to provide an organized structure for future spatial analysis, LU/LC layer data model is prepared. While creating the LU/LC database from Visual Interpretation Techniques, this data model is followed. Further, Overlay analysis is carried out, which helps in visualizing in-depth decadal changes that occurred in Land-Use patterns. The process flow followed for the LU/LC change detection is shown in Figure 3.17.

Figure 3.17 Process outline for LULC change detection



Land-Use/ Land-Cover (LU/LC) layer data model - The geometrically corrected Resource Sat-2 LISS-IV data for the desired framework is the primary input for LU/LC classification and mapping. The survey of India's topographic map layer on a 1:500,000 scale is used as the base layer. A good amount of collateral data on themes like a wasteland, forest, vegetation, etc. is used as an important source of reference for LU/LC classification as shown in Table 3.17. These legacy layers are re-projected as per the current mapping specifications, WGS 1984_UTM 43N is the projection system used.

Table 3.17 Land use/Land cover classification table for the project study area

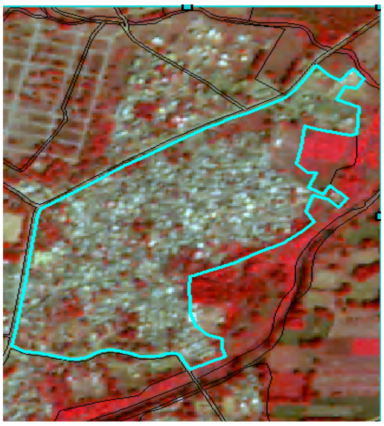
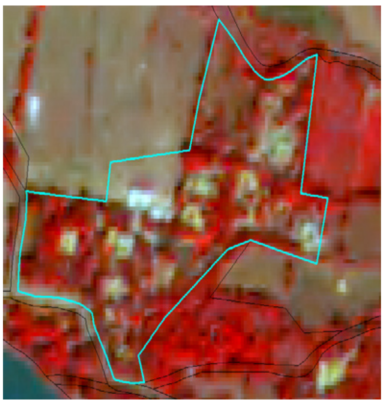
	Level - I	Level - II	Level - III
1	Built Up	Built Up (Urban)	Built Up (Urban)
		Built Up (Rural)	Built Up (Rural)
		Industrial/Mining	Industrial/Mining
		Transportation	Transportation
2	Agricultural Land	Crop land	Crop land
		Agriculture plantation	Agriculture plantation
3	Forest	Forest	Forest
4	Wastelands	Scrub land	Scrub land Dense
			Scrub land Open
		Sandy areas	Sandy areas
		Barren rocky	Barren rocky
		Waterlogged	Waterlogged

	Level - I	Level - II	Level - III
5	Water bodies	River / Stream / Drain	River / Stream / Drain
		Canal	Canal
		Lakes / Ponds	Lakes / Ponds
		Reservoir / Tanks	Reservoir / Tanks

To match the LU/LC classification and mapping on the best possible scale using the LISS-IV, the LU/LC layer data model table was derived from SIS- DP manual (NRSC, 2009) published by NRSC (ISRO). Based on the above-described inputs and the reference data visual interpretation is conducted for 2022 imagery.

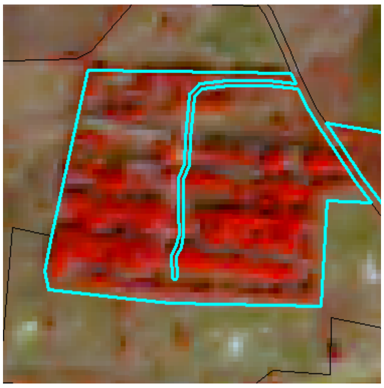
Classification algorithm - Land use refers to human activities and the various uses, which are carried out on land. Land cover refers to natural vegetation, water bodies, rock/soil, etc. The following categories are enlisted to give a detailed description of the characteristics of a particular feature that is used in preparing the LU/LC feature dataset. As per the SIS-DP manual LU/LC is classified into 3 different levels. Level 1 is build-up is sub-classified as Built-Up (Urban), Built-Up (Rural), Industrial/Mining, and Transportation. Agricultural land is classified as cropland and Agriculture plantation. Wastelands are classified as Scrub land Dense, Scrub land Open, Sandy areas, Barren rocky, and waterlogged areas. Water bodies are subdivided into Rivers/Streams / Drains, Canals, Lakes / Ponds, and Reservoir / Tanks. A few classes which are prominently classified in the study area are briefed by taking screen shots of the LISS IV images. Some examples of each LU/LC class are given in Table 3.18; accordingly, LISS IV satellite images are classified.

Table 3.18 Sample for LULC classification

	**Built-up (Urban):** The Land used for human settlement of a population of more than 5000 of which more than 75% of the workforce is involved in non-agricultural activities. These settlements are usually larger in spatial extent than rural settlements and most of the land is covered by building structures in parks, institutions, playgrounds, and other open spaces within built-up areas. **Sample location:** Sandur Taluk
	**Built-up (Rural):** These are built-up land in rural areas of size comparatively less than the urban settlement of which more than 80% of people are involved in agricultural activities and non-commercial activities generally limited support facilities that are unique to an urban area like hospitals, industries, institutions, etc. **Sample location:** Doulathpura Village

Crop land: These are the areas with standing crops as of the date of the satellite overpass. Cropped areas appear in bright red to red in color with varying shapes and sizes in a contiguous to the non-contiguous pattern. They are widely distributed in different terrains; prominently appear in the irrigated areas irrespective of the source of irrigation.

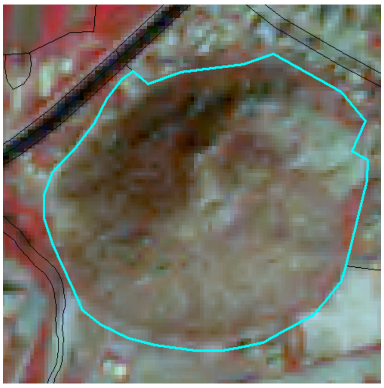
Sample location: Doulathpura Village



Agriculture/Horticulture plantation:

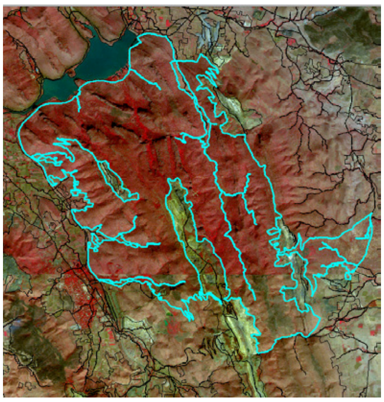
These are the areas under agricultural tree crops planted by adopting certain agricultural management techniques. This category includes the horticulture areas that refer to the cultivation of coconut, areca nut, citrus fruits, orchards and other horticultural nurseries, herbs, shrubs, fruits, ornamental shrubs, and trees, vegetable gardens, etc.

Sample location: Sandur Taluk



Barren rocky: These are rock exposures of varying lithology often barren and devoid of soil and vegetation cover. They occur amidst hill forests as openings or as isolated exposures on plateaus and plains. They appear in greenish blue to yellow to brownish in colour depending on the rock type. They vary in size with irregular to discontinuous shapes with a linear to the contiguous or dispersed pattern.

Sample location: Near Daroji lake

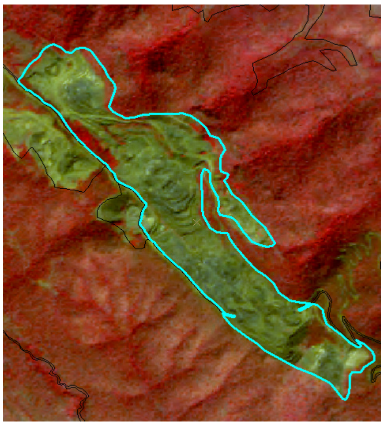
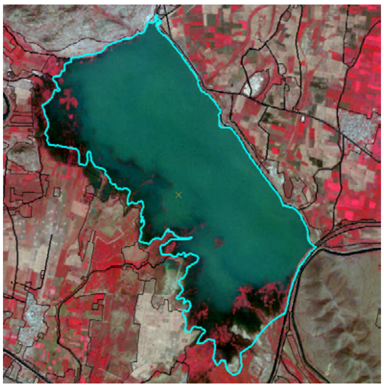
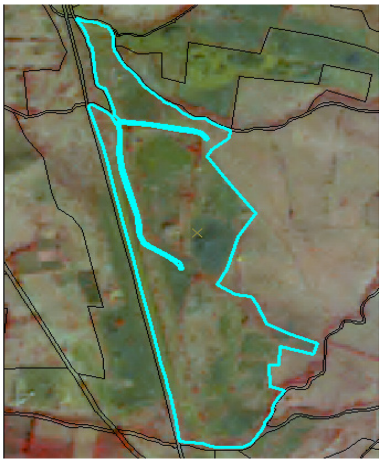
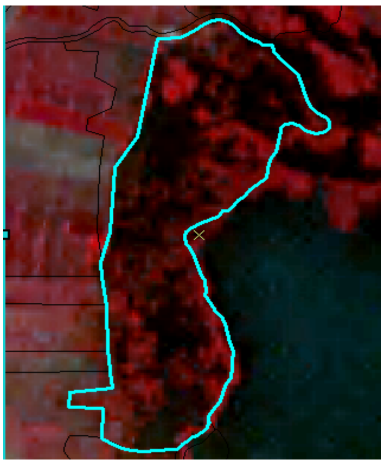


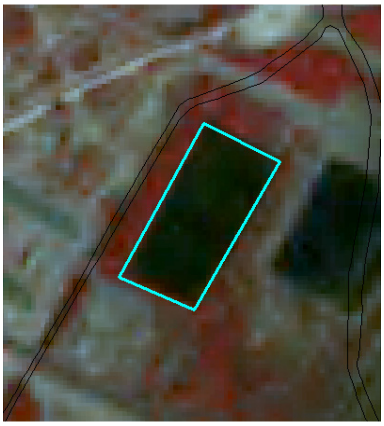
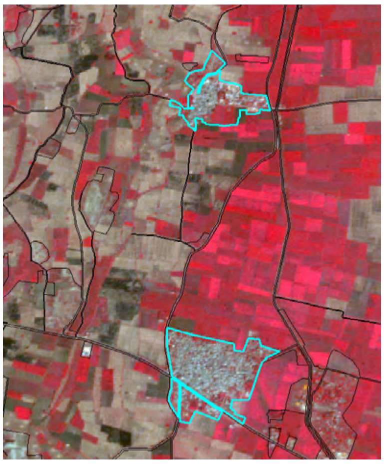
Forest: These are the areas bearing an association predominantly of trees and other vegetation types (within the notified forest boundaries) capable of producing timber and other forest produce.

Sample location: Marutla extension

Industrial: Industrial areas where human activity is observed in the form of manufacturing along with supporting establishments such as maintenance, engineering plants, petrochemical, thermal, cement industries, etc., are included under this.

Sample location: JSW plant

	**Mining:** Mine/quarry is the areas subjected to removal of earth material (both surficial and sub-surficial) by manual and mechanized operations. Large-scale quarrying and mechanization results in mining and mine dump. It includes surface rocks and stone quarries, sand and gravel pits, brick kilns, and associated features like mine dumps, abandoned mine pits, etc. **Sample location:**Ramanmalai Forest area
	**Reservoir/Tanks:** A reservoir is an artificial lake created by the construction of a dam across the river specifically for hydel power generation, irrigation, and water supply for domestic/industrial needs, and flood control, either Single or in combination. Tanks are small lakes of impounded waterways constructed on land surfaces for irrigation. They appear in light blue to dark blue depending on the depth from small to large sizes. They possess regular to irregular shapes dispersed to linear, occupying lowlands, and plains. **Sample location:** Daroji lake
	**Scrub land:** These areas possess shallow and skeletal soils, at times chemically degraded, extremes of slopes, severely eroded and lands subjected to excessive aridity with scrubs dominating the landscape. They have a tendency for intermixing with cropped areas. **Sample location:** BTP junction
	**Waterlogged:** Waterlogged land is low-lying land where the water is at/or near the surface and the water stands for the most part of the year. **Sample location:** Near Daroji lake

	**Lakes/ponds:** Lakes/ponds are those that retain water in them either for one season or throughout the year and are usually not subject to extreme fluctuation in water level. Ponds are the body of water-limited in size, either natural or artificial, regular in shape, smaller in size than a lake, and generally located near settlements **Sample location:** Kuduthini Village
	**Villages:** These are built-up areas in rural areas, smaller in size, mainly associated with agriculture and allied sectors and non-commercial activities with a population size of less than 5000, generally limited supporting facilities that are unique to urban areas like hospitals, industries, institutions, etc. There are different types of rural settlements based on the extent of the built-up area and inter-house distance. **Sample location:** Madapuram and Hosadaroji Village

4 Devadari DHPC

The construction of Devadari Downhill Pipe Conveyor is completed and shall operate soon. To understand the baseline condition of the study area, the environemental attributes given in the ToRs are assessed and the results are as follows.

4.1 ToR I

Water bodies were identified within 1 km area on either side of the DHPC as per ToRs through satellite imageries and ground truth verification was done for the same. Through field studies Hulikunte Lake was the only water body identified in the study area, details of the waterbody is given in Table 4.1.

Table 4.1 List of water bodies inventoried

	Water body	Distance (m)	Remarks	GPS Coordinates	
				Latitude	Longitude
1	Hulikunte Lake	900	Perennial	15.063 N	76.553 E

Hulikunte Lake is a perennial water body spread over an area of 23.91 Ha. Google earth imagery of the water body is given in Figure 4.1.

Figure 4.1 Hulikunte Lake google earth imagery

4.2 ToR II

4.2.1 Surface water

The surface water monitoring results of Hulikunte Lake is given in Table 4.2, and the results are compared with designated water criteria given by CPCB.

Table 4.2 Hulikunte Lake surface water quality results

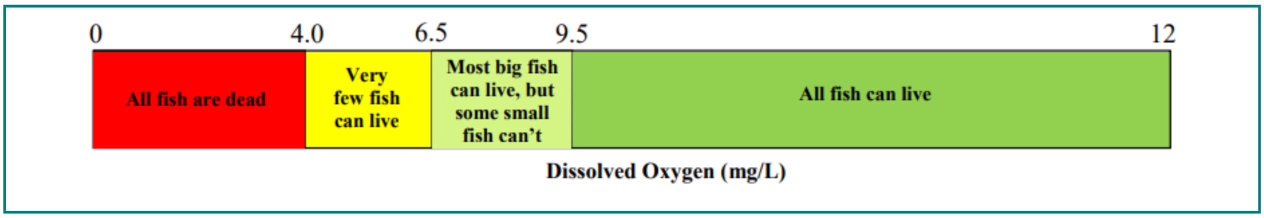
	Particular	Units	Water Quality Criteria					Season I	Season II	Season III
			A	B	C	D	E			
1	pH at 25°C		6.5 – 8.5				6 – 8.5	7.7	7.8	7.6
2	Odour	--	-	-	-	-	-	Odourless		
3	Colour	Hazen	-	10	300	300	-	1	2	2
4	TDS	mg/L	500	-	1500	-	2100	165	197	181
5	Chloride	mg/L	250	-	600	-	600	55	59.9	80.0
6	Sulphate	mg/L	400	-	400	-	1000	20.8	9.6	21.8
7	Fluoride	mg/L	-	-	-	-	-	0.3	0.1	BDL
8	Boron	mg/L	-	-	-	-	<2	BDL	BDL	BDL
9	Sodium	mg/L	-	-	-	-	-	26	15.2	2
10	Iron	mg/L	-	-	-	-	-	5.1	0.7	0.54
11	Oil & Grease	mg/L	-	-	-	-	-	4.2	1	1.45
12	TSS	mg/L	-	-	-	-	-	367	3	5
13	TVS	mg/L	-	-	-	-	-	13	0.2	0.16
14	DO	mg/L	≥6	≥5	≥4	≥4	-	4.6	3.8	3.87
15	COD	mg/L	-	-	-	-	-	11.5	8	16
16	BOD	mg/L	≤2	≤3	≤3	-	-	BDL	BDL	BDL
17	Sulphide	mg/L	-	-	-	-	-	BDL	BDL	BDL
18	RSC	mg/L	-	-	-	-	-	BDL	BDL	BDL
19	Phosphate	mg/L	-	-	-	-	-	0.6	0.3	0.7
20	Total coliform	MPN/ 100mL	≤50	≤500	≤5000	-	-	49	94	130
21	Faecal coliform		-	-	-	-	-	<1.8	2	6.8
Water quality category as per CPCB standards								**C**	**E**	**E**

Note:A - Drinking water source without conventional treatment but after disinfection
B - Outdoor bathing (Organised)
C - Drinking water source after conventional treatment and disinfection
D - Propagation of wild life and fisheries
E - Irrigation, industrial cooling, controlled waste disposal
BDL-Below Detection Limit, MPN- Most Probable Number, mg/L- Milligram per Litre.
*3 days @ 27°C

The pH value in the study area varied from 7.6 to 7.8, which indicates that Hulikunte Lake water is near neutral. The BOD levels in the water sample were Below Detectable Limit in all the season, COD varied from 8 to 16 mg/L. The DO range varied from 3.8 to 4.6 mg/L, if the DO levels decrease to 3-4 mg/L it leads to suffocation and death of fish. Generally, the DO of healthy water should be 6.5 to 8 mg/L, this indicates that the Lake water is not very suitable for aquatic life (https://

www.enr.gov.nt.ca/sites/enr/files/dissolved_oxygen.pdf). The impact of DO levels on aquatic life is given in Figure 4.2.

Figure 4.2 Dissolved oxygen levels and there impact on aquatic life



The results of all the analysed parameters are well within CPCB limit except DO which has resulted in poor water quality category. Accordingly, the water quality category of Hulikunte Lake was Category C during season I and category E during season II and III. This indicates that the Lake water cannot be directly used for drinking water purpose but can be used for irrigation and industrial use.

4.2.2 Groundwater

The groundwater results are compared with IS 10500:2012 drinking water quality standards. The groundwater monitoring results of Lakshmipura extension is given in Table 4.3

Table 4.3 Lakshmipura extension groundwater results

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5 - 8.5	NR	7.4	7.3	7.3
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	1410	891	1036
5	Chloride	mg/L	250	1000	216	224.9	179.9
6	Sulphate	mg/L	200	400	77.7	71.4	80.1
7	Fluoride	mg/L	1	1.5	0.6	0.4	BDL
8	Boron	mg/L	0.5	1	0.2	0.05	0.14
9	Calcium	mg/L	75	200	189.2	208.4	178
10	Sodium	mg/L	--		111	111	61.2
11	Iron	mg/L	0.3	NR	0.1	0.5	1.2
12	Turbidity	mg/L	1	5	0.7	0.2	0.6
13	Total Hardness	mg/L	200	600	684	688	676
14	Magnesium	mg/L	30	100	51.5	40.8	56.4
15	Nitrate	mg/L	45	NR	9.0	8.2	8.4
16	Total Alkalinity	mg/L	200	600	520	490	470
17	Potassium	mg/L	--		2	2	0.8
18	Copper	mg/L	0.05	1.5	0.08	BDL	0.05
19	Manganese	mg/L	0.1	0.3	0.05	0.08	0.05
20	Zinc	mg/L	5	15	BDL	0.04	BDL
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
22	Lead	mg/L	0.01	NR	BDL	0.30	BDL
23	Total Chromium	mg/L	0.05	NR	0.07	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	BDL	0.032	0.077
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	BDL	BDL	0.009
28	Total Coliform	MPN/100mL	Nil		48	79	2
				WQI	**C**	**D**	**E**
Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.							

Result revealed that Total Dissolved Solids were found to be beyond the acceptable limit in season I (1410 mg/L) and season III (676 mg/L) due to the presence of higher content of Bicarbonate, Calcium, Magnesium, Chloride, Sulphate ions, etc. in groundwater (Nawlakhe *et al.*, 1995 & Singh and Somashekhar, 2015). Copper (0.08 mg/L) concentration in season I and Lead (0.3 mg/L) concentration in season II was beyond the permissible limit whereas Iron (1.2 mg/L) and Aluminium (0.07 mg/L) content exceeded the permissible limit during season III followed by season II and season I. Higher heavy metals concentration is due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009 and Su *et al.*, 2014). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

The groundwater monitoring results of Seenibasappa camp is given in Table 4.4.

Table 4.4 Seenibasappa camp groundwater results

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5 - 8.5	NR	7.4	7.6	6.9
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	937	639	725
5	Chloride	mg/L	250	1000	118	119.6	145
6	Sulphate	mg/L	200	400	38.3	33.2	40.2
7	Fluoride	mg/L	1	1.5	0.6	0.4	BDL
8	Boron	mg/L	0.5	1	BDL	BDL	BDL
9	Calcium	mg/L	75	200	211.6	142.7	128.3
10	Sodium	mg/L	--		64.8	71.2	46.4
11	Iron	mg/L	0.3	NR	0.1	0.4	**0.2**
12	Turbidity	mg/L	1	5	2.4	0.4	1.3
13	Total Hardness	mg/L	200	600	556	516	**616**

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
14	Magnesium	mg/L	30	100	6.8	38.9	71.9
15	Nitrate	mg/L	45	NR	8.2	7.6	8.4
16	Total Alkalinity	mg/L	200	600	540	450	454
17	Potassium	mg/L	--		1.6	1.2	BDL
18	Copper	mg/L	0.05	1.5	BDL	0.05	BDL
19	Manganese	mg/L	0.1	0.3	0.04	BDL	BDL
20	Zinc	mg/L	5	15	0.03	BDL	0.09
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL
22	Lead	mg/L	0.01	NR	0.03	0.33	BDL
23	Total Chromium	mg/L	0.05	NR	0.05	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	0.101	BDL	0.206
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	0.003	BDL	0.005
28	Total Coliform	MPN/100mL	Nil		**120**	**<1.8**	**13**
				WQI	**C**	**B**	**A**

Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.

Result showed that Total Dissolved Solids were beyond the acceptable limit in all the seasons with the highest recorded in season I (937 mg/L) due to the presence of higher content of Bicarbonate, Calcium, Magnesium, Chloride, Sulphate ions, etc. in groundwater (Nawlakhe *et al.*, 1995 & Singh and Somashekhar, 2015). Total hardness was beyond the acceptable limit in all the seasons due to the presence of Calcium and Magnesium ions (Suresh and Kottureshwara, 2009). Iron (0.4 mg/L), Lead (0.3 mg/L) concentration in season II, and Aluminium (0.2 mg/L) concentration in season III exceeded the permissible limit. Higher heavy metals concentration is due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009 and Su *et al.*, 2014). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

The groundwater monitoring results of Chikkasandur is given in Table 4.5.

Table 4.5 Chikkasandur groundwater results

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5 - 8.5	NR	7.0	7.3	7.0
2	Odour		Agreeable		odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	1017	838	835
5	Chloride	mg/L	250	1000	301	319.9	399

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
6	Sulphate	mg/L	200	400	73.5	38.1	33.2
7	Fluoride	mg/L	1	1.5	0.4	0.3	BDL
8	Boron	mg/L	0.5	1	0.2	0.16	0.11
9	Calcium	mg/L	75	200	290.2	168.3	165.1
10	Sodium	mg/L	--		57.2	54.4	44
11	Iron	mg/L	0.3	NR	0.1	0.2	**0.5**
12	Turbidity	mg/L	1	5	2.5	3.2	1.2
13	Total Hardness	mg/L	200	600	**1000**	480	496
14	Magnesium	mg/L	30	100	67.1	14.6	20.4
15	Nitrate	mg/L	45	NR	9.2	7.6	7.9
16	Total Alkalinity	mg/L	200	600	600	430	280
17	Potassium	mg/L	--		0.8	0.4	0.8
18	Copper	mg/L	0.05	1.5	BDL	BDL	BDL
19	Manganese	mg/L	0.1	0.3	BDL	BDL	0.06
20	Zinc	mg/L	5	15	1.8	BDL	BDL
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL
22	Lead	mg/L	0.01	NR	BDL	0.28	BDL
23	Total Chromium	mg/L	0.05	NR	0.04	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	0.073	0.4	0.1
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	0.004	BDL	0.005
28	Total Coliform	MPN/100mL	Nil		7.8	**430**	**17**
				WQI	**B**	**C**	**D**

Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.

Result revealed that Total hardness (1000 mg/L) was beyond the acceptable limit in season I. This is due to the presence of Calcium and Magnesium ions (Suresh and Kottureshwara, 2009). Total Alkalinity was beyond the acceptable limit in all the seasons due to the presence of a higher concentration of Carbonate and Bicarbonate ions (Thotappaiah *et al.*, 2019). Iron (0.5 mg/L) concentration in season III, Lead (0.2 mg/L), and Aluminium (0.4 mg/L) concentration in season II exceeded the permissible limit. Higher heavy metals concentration is due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009 and Su *et al.*, 2014). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

The groundwater monitoring results for Bhujanganagar school given in Table 4.6.

Table 4.6 Bhujanganagar school groundwater results

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5 - 8.5	NR	7.4	7.6	7.5
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	1065	794	722
5	Chloride	mg/L	250	1000	217.9	244.9	199
6	Sulphate	mg/L	200	400	43.7	58.8	53.4
7	Fluoride	mg/L	1	1.5	0.5	0.4	BDL
8	Boron	mg/L	0.5	1	0.09	BDL	BDL
9	Calcium	mg/L	75	200	194	166.7	262.9
10	Sodium	mg/L	--		59.2	54.8	48.8
11	Iron	mg/L	0.3	NR	0.1	0.03	**0.5**
12	Turbidity	mg/L	1	5	0.5	0.4	2.5
13	Total Hardness	mg/L	200	600	492	488	976
14	Magnesium	mg/L	30	100	1.9	17.5	77.8
15	Nitrate	mg/L	45	NR	2.1	1.8	8.6
16	Total Alkalinity	mg/L	200	600	350	310	**438**
17	Potassium	mg/L	--		2.4	1.6	BDL
18	Copper	mg/L	0.05	1.5	BDL	BDL	BDL
19	Manganese	mg/L	0.1	0.3	BDL	BDL	0.05
20	Zinc	mg/L	5	15	BDL	BDL	BDL
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL
22	Lead	mg/L	0.01	NR	BDL	**0.32**	BDL
23	Total Chromium	mg/L	0.05	NR	0.04	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	0.073	BDL	0.097
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	0.004	BDL	0.017
28	Total Coliform	MPN/100mL	Nil		**7.8**	**2**	**23**
				WQI	**B**	**A**	**D**

Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.

Result showed that Total hardness was beyond the permissible limit in season I due to the presence of Calcium and Magnesium ions (Suresh and Kottureshwara, 2009).Total Dissolved Solids were beyond the acceptable limit in all the seasons with highest recorded in season I (1065 mg/L) due to the presence of higher content of Bicarbonate, Calcium, Magnesium, Chloride, Sulphate ions, etc. in groundwater (Nawlakhe *et al.*, 1995 & Singh and Somashekhar, 2015). Total alkalinity was beyond the acceptable limit in all the seasons due to the presence of a higher concentration of Carbonate and Bicarbonate ions (Thotappaiah *et al.*, 2019). Similarly Iron (0.5 mg/L), Aluminium

(0.09 mg/L) concentration in season III whereas Lead (0.3 mg/L) concentration in season II were found to be beyond the permissible limit due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009 and Su *et al.*, 2014). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

Human health effects: Drinking hard water causes diarrhoea (WHO, 2010) whereas consumption of excessive amount of alkaline water reduces natural acid in the stomach and leads to anxiety and irritability (Rane *et al.*, 2022). The presence of higher Iron content in human body causes liver cancer, diabetes, infertility etc. (Kumar *et al.*, 2017) whereas excess Aluminium presence results in the development of Alzheimer disease (WHO, 2003). Acute Lead intoxication causes headache, abdominal cramps, kidney damage and chronic toxicity results in tiredness, sleeplessness, irritability, joint pain etc. (WHO, 2003). Acute exposure of Copper leads to headache, vomiting etc. and long-term exposure causes nausea, abdominal pain, diarrhoea etc. (WHO, 2004). The presence of coliforms in drinking water causes diarrhoea, nausea and fever in infants (WHO, 2017).

4.3 ToR III

The ambient air quality results are compared with NAAQ Standards specified by CPCB. The results of Devadari hopper point is given in Table 4.7.

Table 4.7 Ambient Air Quality results for Devadari hopper point

Parameter	CPCB Stds.	Season I	Season II	Season III
PM_{10}	100	**345.5**	**269.2**	**280**
$PM_{2.5}$	60	**102.9**	**90.7**	**93.4**
SO_2	80	BDL	3.1	BDL
NO_2	80	6.3	9.7	8.6

The AAQM results of Devadari hopper point revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards. The results of Devadari transfer point is given in Table 4.8.

Table 4.8 Ambient Air Quality results for Devadari transfer point

Parameter	CPCB Stds.	Season I	Season II	Season III
PM_{10}	100	**462.8**	**299.3**	**352.3**
$PM_{2.5}$	60	**132.4**	**104.3**	**117.5**
SO_2	80	BDL	3.6	4.9
NO_2	80	21.7	11.1	15.5

The AAQM results of Devadari transfer point revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards. The results of Bhujanganagar school is given in Table 4.9.

Table 4.9 Ambient Air Quality results for Bhujanganagar school

Parameter	CPCB Stds.	Season I	Season II	Season III
PM_{10}	100	**331.4**	**258.6**	**284.2**
$PM_{2.5}$	60	**98.1**	**79.2**	**94.4**
SO_2	80	BDL	3.7	5.6
NO_2	80	20.4	11.2	17.1

The AAQM results of Bhujanganagar school revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards. The results of Lakshmipura village are given in Table 4.10.

Table 4.10 Ambient Air Quality results for Lakshmipura village

Parameter	CPCB Stds.	Season I	Season II	Season III
PM_{10}	100	**240.2**	**159.4**	**196.1**
$PM_{2.5}$	60	**73.8**	54.8	**65.1**
SO_2	80	BDL	BDL	4
NO_2	80	9.6	6.1	12.3

The AAQM results of Lakshmipura village revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards. A graphical representation of PM_{10} and $PM_{2.5}$ for all three seasons is given in Figure 4.3 and 4.4 respectively.

Figure 4.3 Seasonal variation of PM_{10} – Devadari DHPC

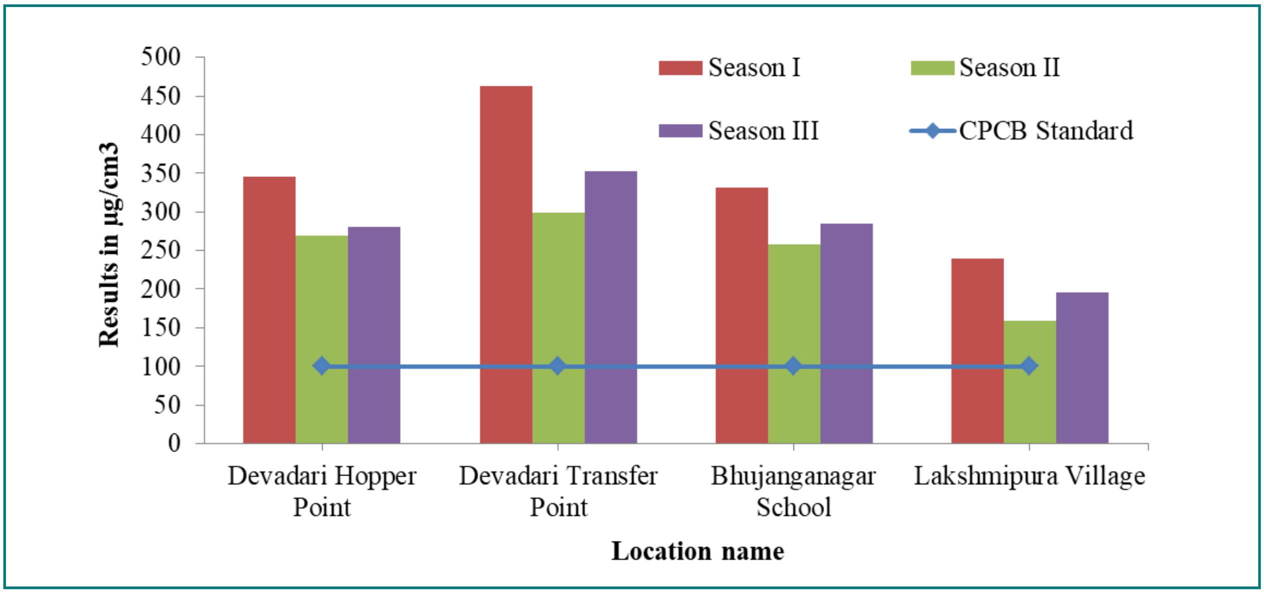
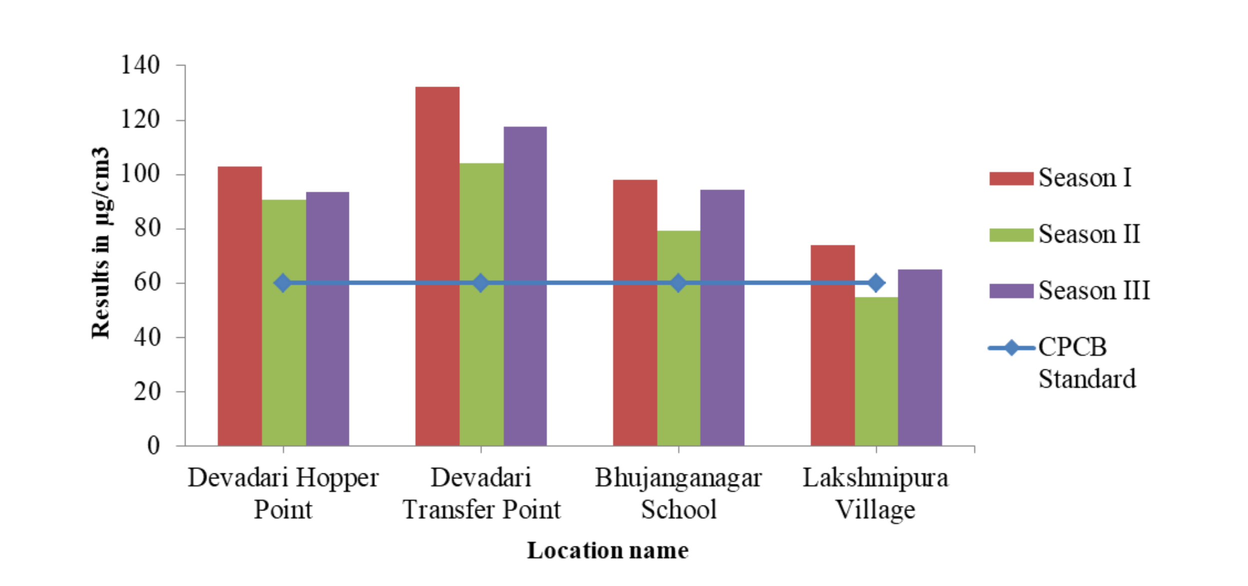


Figure 4.4 Seasonal variation of $PM_{2.5}$ – Devadari DHPC



Overall the PM_{10} concentration irrespective of locations and seasons exceeded the National Ambient Air Quality Standards. Except Lakshmipura village (54.8µg/m^3) in season II the $PM_{2.5}$ concentration in the rest of the locations and seasons was beyond the National Ambient Air Quality Standards. This is due to a rise in dust levels from vehicles transporting Iron ore and as a result, the Particulate Matter concentration increased. Highest Particulate Matter concentration was recorded in Devadari transfer point (PM_{10} - 462.8µg/m^3 and $PM_{2.5}$ - 132.4µg/m^3) whereas, in season II, the lowest Particulate Matter concentration was recorded in Lakshmipura village (PM_{10} - 159.4µg/m^3 and $PM_{2.5}$ - 54.8µg/m^3). The Particulate Matter concentration (PM_{10} and $PM_{2.5}$) in all the locations was higher in the season I followed by season III and season II. This is due to the increase in temperature in the season I which in turn accelerated the concentration of Particulates in the ambient air (Ingole and Jane, 2020). The Sulphur dioxide and Nitrogen dioxide concentration in all locations and seasons were found to be within the National Ambient Air Quality Standards. The AQI category in the study area varied from each season. Details of AQI category is given in Table 4.11. The Air Quality Index in the study area was better in season II compared to that of the season I and III.

Table 4.11 AQI category for Devadari DHPC locations

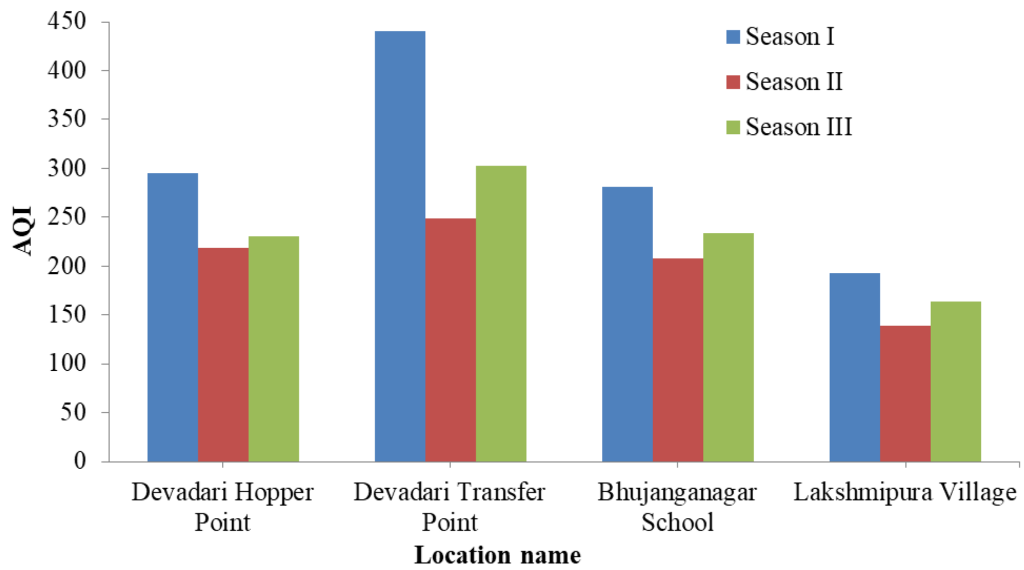
	Locations	AQI category		
		Season I	Season II	Season III
1	Devadari hopper point	Poor	Poor	Poor
2	Devadari transfer point	Severe	Poor	Very poor
3	Bhujanganagar school	Poor	Poor	Poor
4	Lakshmipura village	Moderate	Moderate	Moderate

In Devadari hopper point and Bhujanganagar school AQI was found to be poor in all three seasons. While, in Lakshmipura Village it was moderate for all three seasons. In Devadari transfer point the AQI was found to be severely polluted in season I and in season II & III it was poor and very poor. The Air Quality Index in the study area was better in season II compared to that of the season I and III. AQI results revealed that the ambient air quality in Bhujanganagar school and

Lakshmipura village was poor and moderate, control measures need to be taken by concerned authorities to reduce the air pollution in the area/region.

A graphical representation for AQI seasonal variation is given in Figure 4.5.

Figure 4.5 Seasonal variation of AQI – Devadari DHPC



Human health effects: The short term exposure to Particulate Matter (PM_{10} and $PM_{2.5}$) leads to lungs, respiratory infections and aggravated asthma whereas long-term exposure results in stroke, heart disease and cancer etc. (WHO, 2021).

4.4 ToR IV

The ambient noise monitoring results are given in Table 4.12 and compared with CPCB standards.

Table 4.12 Ambient noise monitoring results

Location name	Zone/Area	CPCB std. dB(A)		Season I		Season II		Season III	
		Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)
Devadari hopper point	Silence	50	40	54.1	55.9	61	61.4	59.2	58
Devadari transfer point	Silence	50	40	65.8	64.4	60.1	59.8	67.6	66.8
Bhujanganagar school	Silence	50	40	67.4	66.2	69.3	69.2	70.4	71.1
Lakshmipura village	Residential	55	45	61.8	61.2	61.5	61.7	66.3	66.7
Note: dB(A)- Decibel in scale A, Leq - Equivalent continuous sound level.									

Irrespective of locations and seasons, the day and night time noise levels were found beyond the CPCB Standards due to vehicular movement, particularly from trucks carrying Iron ore. Further, the night time noise levels were higher in Devadari hopper point (55.9 dB(A) in season I and 61.4 dB(A) in season II), Bhujanganagar school (71.1 dB(A) in season III), and Lakshmipura village (61.7 dB(A) in season II and 66.7 dB(A) in season III) compared to day time noise levels. This is due to the movement of trucks in the early morning between 3 am to 6 am and also natural sounds present in the environment added to the increase in noise levels.

During season III, the Bhujanganagar school recorded the highest day (70.4 dB(A)) and night time (71.1 dB(A)) noise levels whereas Devadari hopper point in season I recorded the lowest day (54.1 dB(A)) and night time (55.9 dB(A)) noise levels respectively. Results revealed that the ambient noise levels in Bhujanganagar school and Lakshmipura village is high and control measures needs to be taken by concerned authorities to reduce the noise pollution in the area/region. The seasonal variation of noise levels during day and night is given in Figure 4.6 and 4.7 respectively.

Figure 4.6 Seasonal variation of noise levels during day

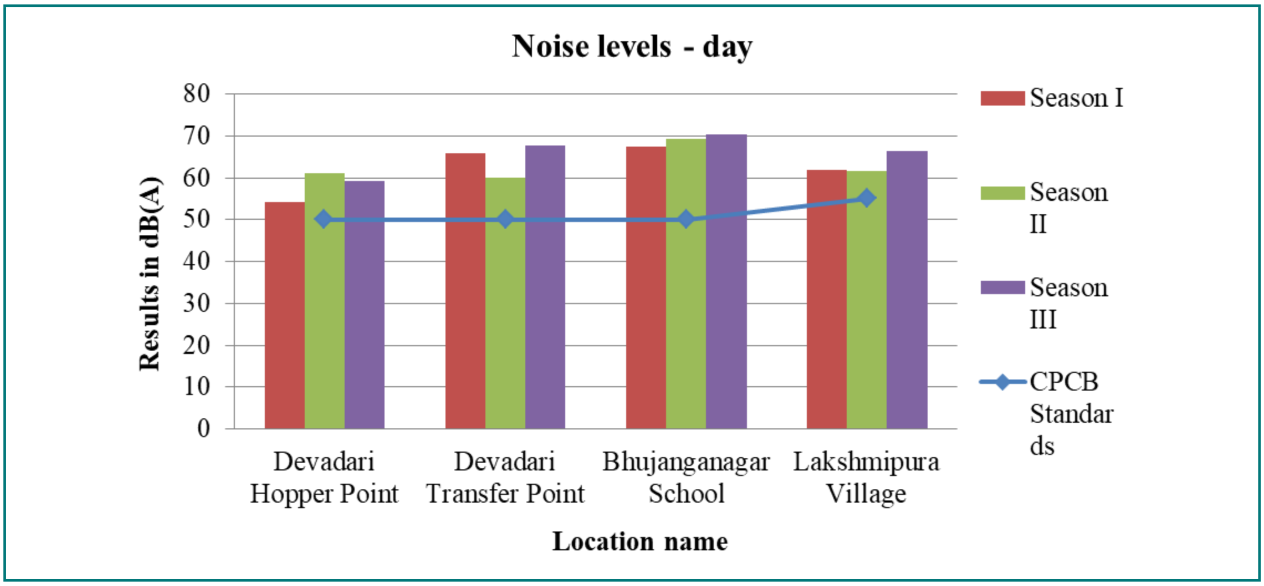
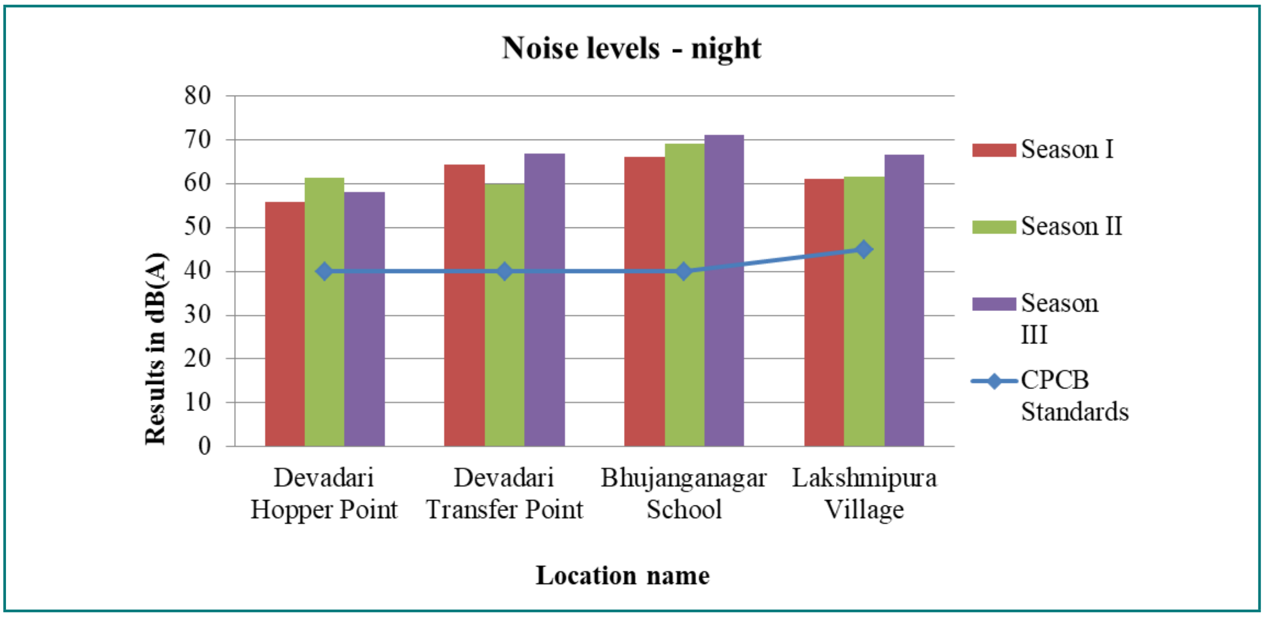


Figure 4.7 Seasonal variation of noise levels during night



Human health effects: Noise exposure i.e., Noise levels greater than 85 dB(A) for 8 h of exposure leads to sleep disturbance, hearing impairment, hypertension, annoyance, etc. (WHO, 2022 and Chepesiuk, 2005).

4.5 ToR V

The soil results for Lakshmipura extension is given in Table 4.13, 4.14, 4.15, and 4.16 respectivley.

Table 4.13 Soil analysis results for Lakshmipura extension

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.2	1.3	1.2
2	Porosity	%	-	-	52.0	51.9	53.6
3	pH	--	<6.5	>8.5	7.2	6.3	7.7
4	Electrical Conductivity	µS/cm	<0.25	>2.25	354	569	427
5	Calcium	mg/kg	-	-	7.5	14	8.5
6	Magnesium	mg/kg	-	-	5.2	5.3	4.6
7	Chloride	mg/kg	< 0.25	>2.0	BDL	2.8	5.6
8	Nitrate	mg/kg	-	-	19.2	25.4	9.1
9	Phosphate	mg/kg	-	-	85.9	204.5	84.1
10	Sulphate	mg/kg	-	-	85.5	16.5	43.9
11	Sodium	mg/kg	-	-	5.7	5.8	7.6
12	Potassium	mg/kg	-	-	2.2	3.5	4.8
13	Water Holding Capacity	%	-	-	52.0	55.4	64.0
14	Sodium Adsorption Ratio	%	-	-	0.1	0.13	0.2
15	Exchangeable Sodium Percentage	%	-	-	0.9	0.6	1.2
16	Sand	%	-	-	74.0	58.5	59.5
17	Silt	%	-	-	18.5	29	30.5
18	Clay	%	-	-	7.4	12.5	10.0
19	Organic Carbon	%	0.5	0.75	0.8	0.9	0.7
20	Organic Matter	%	-	-	1.4	1.5	1.2

Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.

Table 4.14 Soil analysis results for Seenibasappa camp

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.4	1.4	1.2
2	Porosity	%	-	-	46.9	48.6	54.7
3	pH	--	<6.5	>8.5	7.3	7.1	7.7
4	Electrical Conductivity	µS/cm	<0.25	>2.25	309	216	358

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
5	Calcium	mg/kg	-	-	8.2	9.4	7.5
6	Magnesium	mg/kg	-	-	2.2	5.9	0.8
7	Chloride	mg/kg	< 0.25	>2.0	22.7	22.7	19.9
8	Nitrate	mg/kg	-	-	15.5	13.6	17.0
9	Phosphate	mg/kg	-	-	55.5	43.8	46.9
10	Sulphate	mg/kg	-	-	79.8	49.7	81.1
11	Sodium	mg/kg	-	-	3.0	2.5	4.7
12	Potassium	mg/kg	-	-	4.9	2.4	6.9
13	Water Holding Capacity	%	-	-	50.4	52.6	76.0
14	Sodium Adsorption Ratio	%	-	-	0.09	0.06	0.1
15	Exchangeable Sodium Percentage	%	-	-	0.6	0.3	1.1
16	Sand	%	-	-	74.0	67	68.0
17	Silt	%	-	-	18.5	23	23.0
18	Clay	%	-	-	7.4	10	9.0
19	Organic Carbon	%	0.5	0.75	1.2	1.1	1.0
20	Organic Matter	%	-	-	2.0	1.9	1.7
Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.							

Table 4.15 Soil analysis results for Chikkasandur

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.3	1.7	1.00
2	Porosity	%	-	-	49.8	36.8	62.3
3	pH	--	<6.5	>8.5	7.0	7.0	7.5
4	Electrical Conductivity	µS/cm	<0.25	>2.25	198	392	233
5	Calcium	mg/kg	-	-	10.6	17.8	12.8
6	Magnesium	mg/kg	-	-	4.7	9.5	3.0
7	Chloride	mg/kg	< 0.25	>2.0	17.0	17	16.8
8	Nitrate	mg/kg	-	-	7.9	14.6	10.3
9	Phosphate	mg/kg	-	-	30.3	34.1	71.9
10	Sulphate	mg/kg	-	-	15.8	32.7	39.4
11	Sodium	mg/kg	-	-	2.3	5.1	4.0
12	Potassium	mg/kg	-	-	2.5	4.6	5.6
13	Water Holding Capacity	%	-	-	60.4	44.2	84.0
14	Sodium Adsorption Ratio	%	-	-	0.06	0.1	0.1
15	Exchangeable Sodium Percentage	%	-	-	0.3	0.4	0.5
16	Sand	%	-	-	84.7	70	69.0
17	Silt	%	-	-	8.4	26	25.5

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
18	Clay	%	-	-	6.7	4	5.5
19	Organic Carbon	%	0.5	0.75	0.6	0.5	0.5
20	Organic Matter	%	-	-	1.1	0.9	0.8
Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.							

Table 4.16 Soil analysis results for Bhujanganagar school

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.3	1.5	1.4
2	Porosity	%	-	-	51.0	42.7	47.2
3	pH	--	<6.5	>8.5	6.8	7.3	7.2
4	Electrical Conductivity	µS/cm	<0.25	>2.25	310	350	606
5	Calcium	mg/kg	-	-	9.4	14.4	9.5
6	Magnesium	mg/kg	-	-	1.9	4.0	2.0
7	Chloride	mg/kg	< 0.25	>2.0	28.4	28.4	27.3
8	Nitrate	mg/kg	-	-	18.2	12.9	16.8
9	Phosphate	mg/kg	-	-	36.0	41.5	45.4
10	Sulphate	mg/kg	-	-	195.3	102.4	69.9
11	Sodium	mg/kg	-	-	2.9	11.6	5.1
12	Potassium	mg/kg	-	-	2.2	4	5.4
13	Water Holding Capacity	%	-	-	46.8	47.4	72.0
14	Sodium Adsorption Ratio	%	-	-	0.09	0.2	0.1
15	Exchangeable Sodium Percentage	%	-	-	0.5	1.3	0.9
16	Sand	%	-	-	58.8	63	60.0
17	Silt	%	-	-	33.3	30.5	31.5
18	Clay	%	-	-	9.8	6.5	8.5
19	Organic Carbon	%	0.5	0.75	0.5	0.4	0.4
20	Organic Matter	%	-	-	0.8	0.7	0.7
Note: BDL- Below Detection Limit, g/cm3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.							

The soil pH in the study area varied from 6.3 to 7.7. The highest pH was observed in the Lakshmipura extension (7.7) in season III. Results revealed that the pH in the study area was near acidic to alkaline. Electrical conductivity represents the measure of salts present in the soil. It was observed that electrical conductivity in the study area ranged between 198 to 606 µS/cm with the highest recorded in Bhujanganagar school (606 µS/cm) in season III due to the presence of the higher amount of salts in the soil (Yaseen *et al.,* 2015).

Higher phosphate concentration in Lakshmipura extension (204.5 mg/kg) in season II is attributed to anthropogenic activities like fertilizers application, discharge of domestic and industrial wastewater, etc to the soil whereas higher sulphate concentration in Bhujanganagar school (195.3 mg/kg) in the season I is due to the weathering of sedimentary rocks (Patil *et al.*, 2014). Organic carbon greater than 0.75% in Lakshmipura extension and Seenibasappa camp-school revealed the presence of good fertile soil in the area (Ghosh *et al.*, 1983 and Yaseen *et al.*, 2015).

> Organic matter is a key to bind together various components of soil viz Sand, Silt, and Clay. The Organic carbon content and soil percolation capacity are two key indicators of soil health.
>
> "*Food security at stake*" Deccan Herald (March 26, 2023)

The Hydrological Soil Group classificiation is done for the study area samples and the results indicated that the soil in study area is silt or loam.

4.6 ToR VI

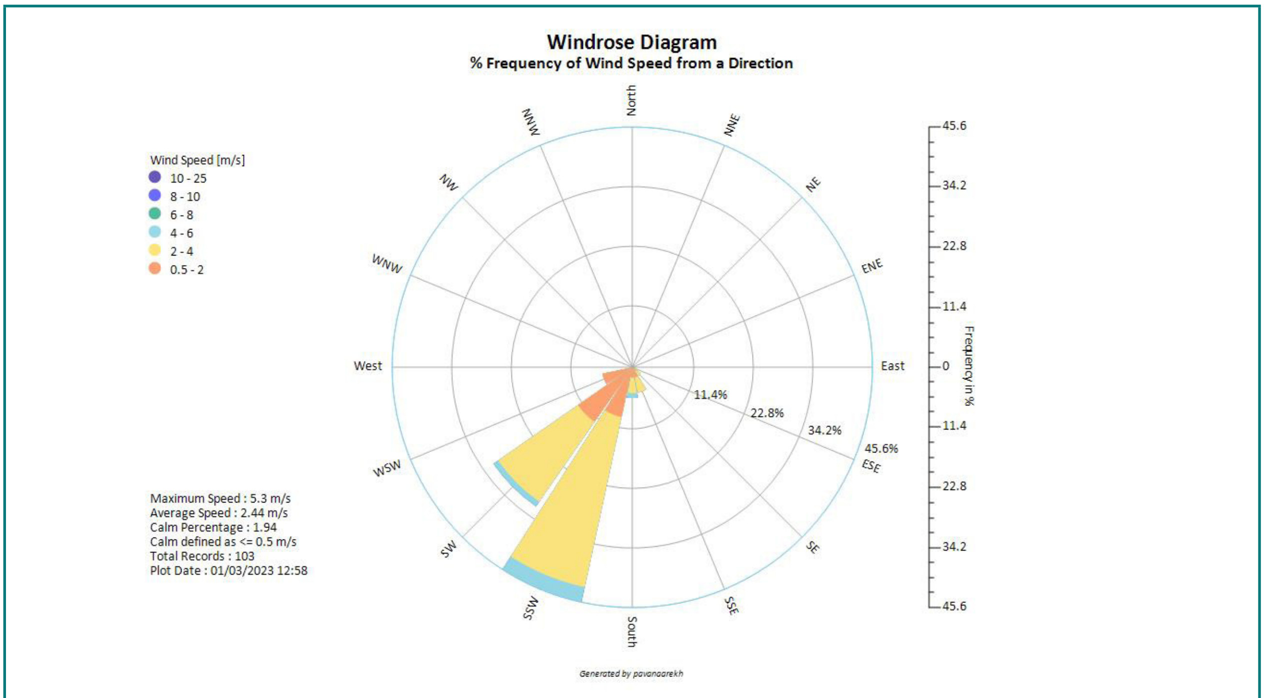
The meterological data is collected from the installed stations considering the study period. The wind rose plot and details of meterological condition for season I are given in the Table 4.17.

Table 4.17 Season I meteorological data

Temperature (°C)		Total Rainfall (mm)	Humidity$_{avg}$ (%)	Wind speed$_{avg}$ (m/s)	Predominant wind direction
Max$_{avg}$	Min$_{avg}$				
25.7	16.9	458	99.6	2.4	SSW

During the first season the predominant wind direction was found to be South South West (SSW), the temperature in the study area varied from 16.9°C to 25.7°C with a total rainfall of 458 mm. The wind rose plot for season I is given in Figure 4.8.

Figure 4.8 Wind rose plot - Season I



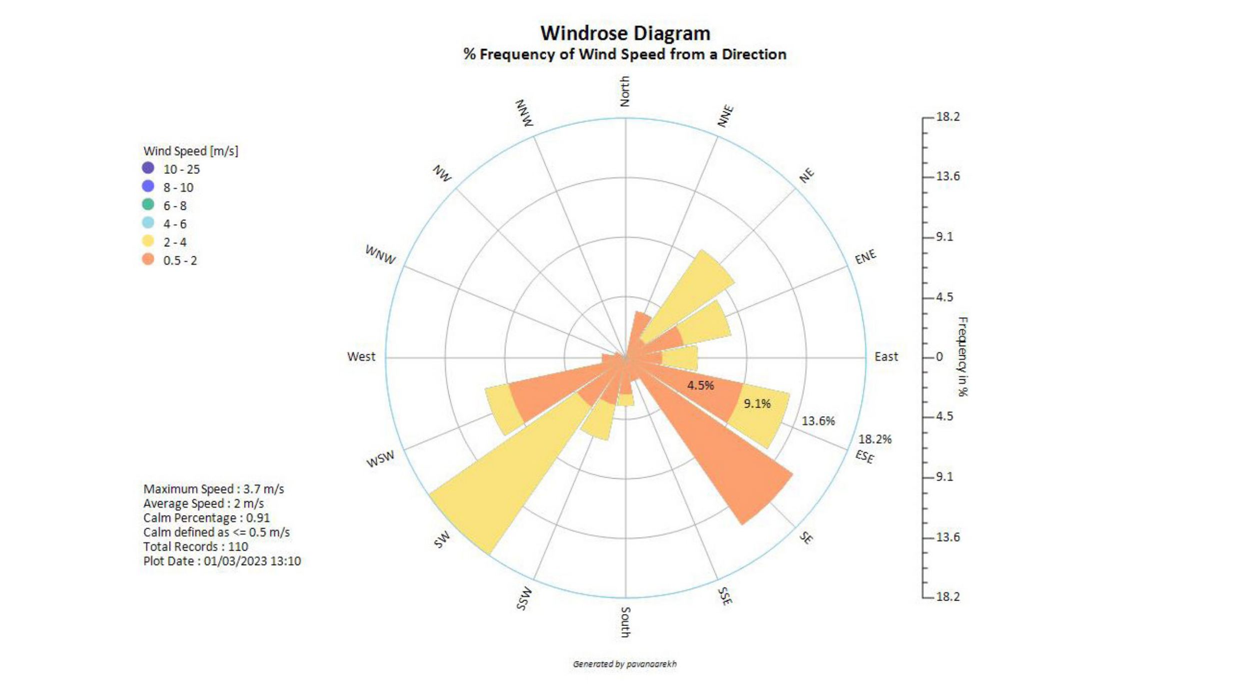
The wind rose plot and details of meterological condition for season II are given in the Table 4.18.

Table 4.18 Season II meteorological data

Temperature (°C)		Total Rainfall (mm)	Humidity$_{avg}$ (%)	Wind speed$_{avg}$ (m/s)	Predominant wind direction
Max$_{avg}$	Min$_{avg}$				
23.7	10.0	232.5	96.4	2.0	SW

During the second season the predominant wind direction was found to be South West (SW), the temperature in the study area varied from 10.7°C to 23.7°C with a total rainfall of 232.5 mm. The wind rose plot for season II is given in Figure 4.9.

Figure 4.9 Wind rose plot - Season II



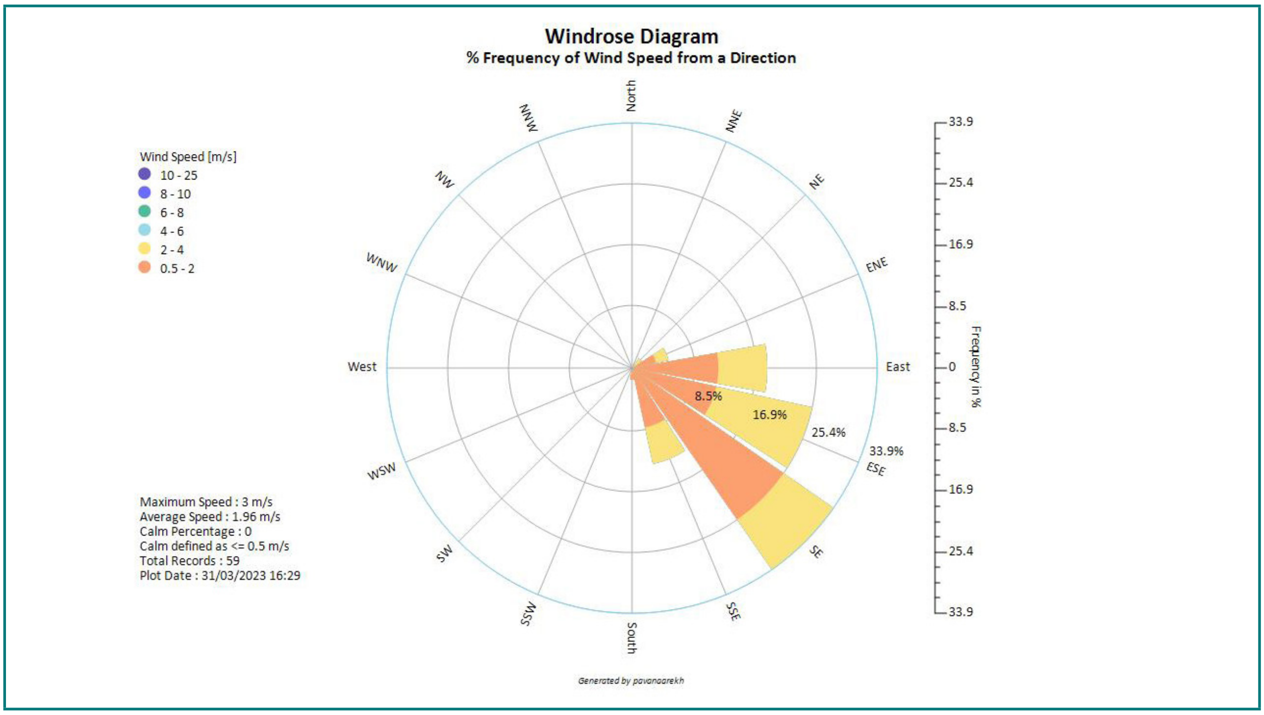
The wind rose plot and details of meterological condition for season III are given in the Table 4.19.

Table 4.19 Season III meteorological data

Temperature (°C)		Total Rainfall (mm)	Humidity$_{avg}$ (%)	Wind speed$_{avg}$ (m/s)	Predominant wind direction
Max$_{avg}$	Min$_{avg}$				
26.3	16.0	1.0	81.2	1.9	SE

During the third season the predominant wind direction was found to be South East (SE). The temperature in the study area varied from 16.0°C to 26.3°C with a total rainfall of 1.0 mm. The wind rose plot for season III is given in Figure 4.10.

Figure 4.10 Wind rose plot - Season III



5 Tunga and Bhadra DHPC

Tunga & Bhadra (TB) DHPC is under the construction phase, environmental attributes are assessed as per the terms of references to obtain baseline data and results are given below.

5.1 ToR I

Water bodies were identified within 1 km area on either side of the DHPC as per ToRs through satellite imageries and ground truth verification was done for the same. During field visit no active water bodies were found in the study area.

5.2 ToR II

5.2.1 Surface water

Due to the absence of active surface water bodies, water samples collection is not done in TB DHPC study area.

5.2.2 Groundwater

The results are compared with IS 10500:2012 drinking water quality standards. The groundwater results for Tunga & Bhadra sponge factory is given in Table 5.1.

Table 5.1 Tunga & Bhadra sponge factory groundwater results

	Particulars	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5- 8.5	NR	7.2	7.5	7.4
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	869	623	738
5	Chloride	mg/L	250	1000	49.9	54.9	115
6	Sulphate	mg/L	200	400	95.9	99.4	86.9
7	Fluoride	mg/L	1	1.5	0.7	0.2	0.1
8	Boron	mg/L	0.5	1	0.1	BDL	BDL
9	Calcium	mg/L	75	200	189.2	126.7	186
10	Sodium	mg/L	--		47.2	46	36.4
11	Iron	mg/L	0.3	NR	0.1	0.1	1
12	Turbidity	mg/L	1	5	0.3	0.6	0.5
13	Total Hardness	mg/L	200	600	500	436	508
14	Magnesium	mg/L	30	100	6.8	29.2	10.7
15	Nitrate	mg/L	45	NR	5.9	5.2	5.8

	Particulars	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
16	Total Alkalinity	mg/L	200	600	460	400	390
17	Potassium	mg/L	--		0.8	BDL	BDL
18	Copper	mg/L	0.05	1.5	BDL	0.03	BDL
19	Manganese	mg/L	0.1	0.3	BDL	BDL	0.05
20	Zinc	mg/L	5	15	0.02	0.07	BDL
21	Cadmium	mg/L	0.003	NR	BDL	0.03	BDL
22	Lead	mg/L	0.01	NR	BDL	0.36	BDL
23	Total Chromium	mg/L	0.05	NR	BDL	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	BDL	BDL	0.038
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	0.002	BDL	0.006
28	Total Coliform	MPN/ 100 mL	Nil		<1.8	70	<1.8
				WQI	**B**	**A**	**D**

Note: AL- Acceptance Limit, PL- Permissible Limit, BDL- Below Detection Limit, NR- No Relaxation, NTU- Nephelometric Turbidity Unit, MPN- Most Probable Number, mg/L- Milligram per Litre.

Result revealed that Total Dissolved Solids, Total hardness and Total alkalinity were beyond the acceptable limit in all the seasons with highest Total Dissolved Solids (869 mg/L), Total hardness (500 mg/L) and Total alkalinity (460 mg/L) recorded in season III. Higher Total Dissolved Solids are due to the presence of higher content of Bicarbonate, Calcium, Magnesium, Chloride, Sulphate ions, etc. in groundwater (Nawlakhe *et al.*, 1995 & Singh and Somashekhar, 2015). Higher hardness is due to the presence of Calcium and Magnesium ions (Suresh and Kottureshwara, 2009) whereas the presence of a higher concentration of Carbonate and Bicarbonate ions resulted in high alkalinity (Thotappaiah *et al.*, 2019). Iron (1.0 mg/L) and Aluminium (0.03 mg/L) concentration in season III, Lead (0.3 mg/L) and Cadmium (0.03 mg/L) concentration in season II exceeded the permissible limit. Higher heavy metals concentration is due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009 and Su *et al.*, 2014). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

The groundwater results for Tunga & Bhadra road intersect is given in Table 5.2.

Table 5.2 Tunga & Bhadra road intersect groundwater results

	Particulars	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5- 8.5	NR	7.3	7.6	7.7
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	755	537	410
5	Chloride	mg/L	250	1000	45.9	49.9	95

	Particulars	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
6	Sulphate	mg/L	200	400	31.7	35.5	68.1
7	Fluoride	mg/L	1	1.5	0.7	0.1	BDL
8	Boron	mg/L	0.5	1	0.1	0.1	0.08
9	Calcium	mg/L	75	200	169.9	160.3	163.5
10	Sodium	mg/L	--		30.4	29.6	16.8
11	Iron	mg/L	0.3	NR	0.07	0.3	0.6
12	Turbidity	mg/L	1	5	0.1	0.8	2.1
13	Total Hardness	mg/L	200	600	476	448	480
14	Magnesium	mg/L	30	100	12.6	11.7	17.5
15	Nitrate	mg/L	45	NR	4.9	4.1	5.1
16	Total Alkalinity	mg/L	200	600	470	430	402
17	Potassium	mg/L	--		0.4	BDL	BDL
18	Copper	mg/L	0.05	1.5	0.3	0.04	BDL
19	Manganese	mg/L	0.1	0.3	0.02	0.01	0.05
20	Zinc	mg/L	5	15	0.2	0.27	BDL
21	Cadmium	mg/L	0.003	NR	BDL	0.04	BDL
22	Lead	mg/L	0.01	NR	BDL	0.38	BDL
23	Total Chromium	mg/L	0.05	NR	BDL	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	BDL	0.4	0.127
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	BDL	BDL	BDL
28	Total Coliform	MPN/ 100 mL	Nil		<1.8	7.8	<1.8
				WQI	**B**	**B**	**D**

Note: AL- Acceptance Limit, PL- Permissible Limit, BDL- Below Detection Limit, NR- No Relaxation, NTU- Nephelometric Turbidity Unit, MPN- Most Probable Number, mg/L- Milligram per Litre.

Result showed that Total Dissolved Solids and Total alkalinity were beyond the acceptable limit in all seasons with highest Total Dissolved Solids (755 mg/L) and Total alkalinity (470 mg/L) recorded in season I. Higher Total Dissolved Solids are due to the presence of higher content of Bicarbonate, Calcium, Magnesium, Chloride, Sulphate ions, etc. in groundwater (Nawlakhe *et al.*, 1995 & Singh and Somashekhar, 2015) whereas the presence of a higher concentration of Carbonate and Bicarbonate ions resulted in high alkalinity (Thotappaiah *et al.*, 2019). Lead (0.3 mg/L), Cadmium (0.04 mg/L), Aluminium (0.4 mg/L) concentration in season II and Iron (1.0 mg/L) concentration in season III exceeded the permissible limit. Higher heavy metals concentration is due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009 and Su *et al.*, 2014). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

The groundwater results for Bannihatti transfer point is given in Table 5.3.

Table 5.3 Bannihatti transfer point groundwater results

	Particulars	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5- 8.5	NR	7.2	7.5	7.8
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	681	191	539
5	Chloride	mg/L	250	1000	26.0	49.9	90
6	Sulphate	mg/L	200	400	28.0	28	57.2
7	Fluoride	mg/L	1	1.5	0.6	0.4	0.05
8	Boron	mg/L	0.5	1	0.1	0.02	0.06
9	Calcium	mg/L	75	200	202	28.9	153.9
10	Sodium	mg/L	--		35.6	26.8	23.6
11	Iron	mg/L	0.3	NR	0.09	0.2	0.5
12	Turbidity	mg/L	1	5	0.01	3.2	1.35
13	Total Hardness	mg/L	200	600	460	160	488
14	Magnesium	mg/L	30	100	10.7	21.4	25.3
15	Nitrate	mg/L	45	NR	8.0	BDL	7.9
16	Total Alkalinity	mg/L	200	600	420	300	378
17	Potassium	mg/L	--		0.4	2.4	BDL
18	Copper	mg/L	0.05	1.5	BDL	0.05	BDL
19	Manganese	mg/L	0.1	0.3	0.02	BDL	0.06
20	Zinc	mg/L	5	15	0.4	0.23	0.3
21	Cadmium	mg/L	0.003	NR	BDL	0.03	BDL
22	Lead	mg/L	0.01	NR	BDL	0.32	BDL
23	Total Chromium	mg/L	0.05	NR	0.06	BDL	BDL
24	Mercury	mg/L	0.001	NR	**4.1**	BDL	BDL
25	Aluminium	mg/L	0.003	NR	0.2	0.3	0.05
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	BDL	BDL	BDL
28	Total Coliform	MPN/ 100 mL	Nil		22	2	<1.8
				WQI	**E**	**B**	**D**

Note: AL- Acceptance Limit, PL- Permissible Limit, BDL- Below Detection Limit, NR- No Relaxation, NTU- Nephelometric Turbidity Unit, MPN- Most Probable Number, mg/L- Milligram per Litre.

In season I, the highest Total Dissolved Solids (681 mg/L) and Total alkalinity (420 mg/L) were recorded. Higher Total Dissolved Solids are due to the presence of higher content of Bicarbonate, Calcium, Magnesium, Chloride, Sulphate ions, etc. in groundwater (Nawlakhe *et al.*, 1995 & Singh and Somashekhar, 2015) whereas the presence of a higher concentration of Carbonate and Bicarbonate ions resulted in high alkalinity (Thotappaiah *et al.*, 2019). Total Chromium (0.06 mg/L) concentration in season I, Lead (0.3 mg/L), Cadmium (0.03 mg/L), Aluminium (0.3 mg/L) concentration in season II and Iron (0.5 mg/L) concentration in season III exceeded the permissible limit. Higher heavy metals concentration is due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009 and Su *et al.*, 2014 and Karunanidhi *et al.*, 2021). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

The groundwater results for Bannihatti school is given in Table 5.4.

Table 5.4 Bannihatti school groundwater results

	Particulars	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5- 8.5	NR	7.7	7.8	7.8
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	761	512	727
5	Chloride	mg/L	250	1000	55.9	64.9	150
6	Sulphate	mg/L	200	400	44.0	45.8	64.9
7	Fluoride	mg/L	1	1.5	0.7	0.1	0.1
8	Boron	mg/L	0.5	1	0.1	0.01	0.09
9	Calcium	mg/L	75	200	145.9	157.1	155.5
10	Sodium	mg/L	--		34.8	36.4	28.8
11	Iron	mg/L	0.3	NR	0.1	0.2	0.2
12	Turbidity	mg/L	1	5	0.2	0.4	1.9
13	Total Hardness	mg/L	200	600	464	428	500
14	Magnesium	mg/L	30	100	24.3	8.7	27.2
15	Nitrate	mg/L	45	NR	7.8	7.4	6.5
16	Total Alkalinity	mg/L	200	600	420	400	398
17	Potassium	mg/L	--		0.8	0.4	BDL
18	Copper	mg/L	0.05	1.5	BDL	0.04	0.05
19	Manganese	mg/L	0.1	0.3	0.02	0.01	0.06
20	Zinc	mg/L	5	15	0.07	0.03	BDL
21	Cadmium	mg/L	0.003	NR	BDL	0.04	BDL
22	Lead	mg/L	0.01	NR	BDL	0.44	0.07
23	Total Chromium	mg/L	0.05	NR	0.04	BDL	BDL
24	Mercury	mg/L	0.001	NR	**2.7**	BDL	BDL
25	Aluminium	mg/L	0.003	NR	0.2	BDL	0.01
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	0.002	BDL	0.004
28	Total Coliform	MPN/ 100 mL	Nil		170	110	110
				WQI	**B**	**B**	**C**

Note: AL- Acceptance Limit, PL- Permissible Limit, BDL- Below Detection Limit, NR- No Relaxation, NTU- Nephelometric Turbidity Unit, MPN- Most Probable Number, mg/L- Milligram per Litre.

Result revealed that Total Dissolved Solids, Total hardness and Total alkalinity were beyond the acceptable limit in all the seasons. Higher Total Dissolved Solids are due to the presence of higher content of Bicarbonate, Calcium, Magnesium, Chloride, Sulphate ions, etc. in groundwater

(Nawlakhe *et al.*, 1995 & Singh and Somashekhar, 2015). Higher hardness is due to the presence of Calcium and Magnesium ions (Suresh and Kottureshwara, 2009) whereas the presence of a higher concentration of Carbonate and Bicarbonate ions resulted in high alkalinity (Thotappaiah *et al.*, 2019). Lead (0.4 mg/L), Cadmium (0.04 mg/L) concentration in season II and Aluminium (0.01 mg/L) concentration in season III exceeded the permissible limit. Higher heavy metals concentration is due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009 and Su *et al.*, 2014). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

Human health effects: Drinking hard water causes diarrhoea (WHO, 2010) whereas consumption of excessive amount of alkaline water reduces natural acid in the stomach and leads to anxiety and irritability (Rane *et al.*, 2022). The presence of higher Iron content in human body causes liver cancer, diabetes, infertility etc. (Kumar *et al.*, 2017) whereas excess Aluminium presence results in the development of Alzheimer disease (WHO, 2003). Acute Lead intoxication causes headache, abdominal cramps, kidney damage and chronic toxicity results in tiredness, sleeplessness, irritability, joint pain etc. (WHO, 2003). High intake of Cadmium leads to osteoporosis, kidney dysfunction etc. (WHO, 2004) whereas Chromium presence in drinking water leads to respiratory, liver, kidney injury etc. (WHO, 2020). The presence of coliforms in drinking water causes diarrhoea, nausea and fever in infants (WHO, 2017).

5.3 ToR III

The results are compared with NAAQ Standards given by CPCB. The ambient air quality results of Bannihatti transfer point is given in Table 5.5.

Table 5.5 Ambient air analysis results – Bannihatti transfer point

Parameter	CPCB Stds.	Season I	Season II	Season III
PM_{10}	100	**266.7**	**184.7**	**218.1**
$PM_{2.5}$	60	**70.9**	**65.2**	**72.9**
SO_2	80	BDL	BDL	BDL
NO_2	80	6.5	4.8	5.5

The AAQM results of Bannihatti transfer point revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards.

The ambient air quality results of Road intersect point is given in Table 5.6.

Table 5.6 Ambient air analysis results - Road intersect point

Parameter	CPCB Stds.	Season I	Season II	Season III
PM_{10}	100	**327.3**	**249.4**	**286.6**
$PM_{2.5}$	60	**99.7**	**90**	**96**
SO_2	80	BDL	BDL	BDL
NO_2	80	7.9	5.5	6.7

The AAQM results of Road intersect point revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards.

The ambient air quality results of 1st pillar point are given in Table 5.7.

Table 5.7 Ambient air analysis results – 1st pillar point

Parameter	CPCB Stds.	Season I	Season II	Season III
PM_{10}	100	**325.8**	**229.3**	**278.9**
$PM_{2.5}$	60	**99.4**	**66.9**	**93.1**
SO_2	80	BDL	BDL	3
NO_2	80	11.2	7.7	9.6

The AAQM results of 1st pillar point revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards.

The ambient air quality results of Bhadra hopper point is given in Table 5.8.

Table 5.8 Ambient air analysis results – Bhadra hopper point

Parameter	CPCB Stds.	Season I	Season II	Season III
PM_{10}	100	**330.4**	**341.4**	**324.3**
$PM_{2.5}$	60	**117.1**	**119.3**	**108.6**
SO_2	80	BDL	4.2	3.2
NO_2	80	10.4	13.1	8.8

The AAQM results of Bhadra hopper point revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards.

The ambient air quality results of Bannihatti school are given in Table 5.9.

Table 5.9 Ambient air analysis results - Bannihatti school

Parameter	CPCB Stds.	Season I	Season II	Season III
PM_{10}	100	**371.8**	**177.6**	**205.4**
$PM_{2.5}$	60	**110.7**	**64.4**	**68.1**
SO_2	80	BDL	BDL	BDL
NO_2	80	BDL	**5.6**	5.9

The AAQM results of Bannihatti school revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards. A graphical representation of PM_{10} and $PM_{2.5}$ for all three seasons is given in Figure 5.1 and 5.2 respectively.

Figure 5.1 Seasonal variation of PM_{10} – Tunga & Bhadra DHPC

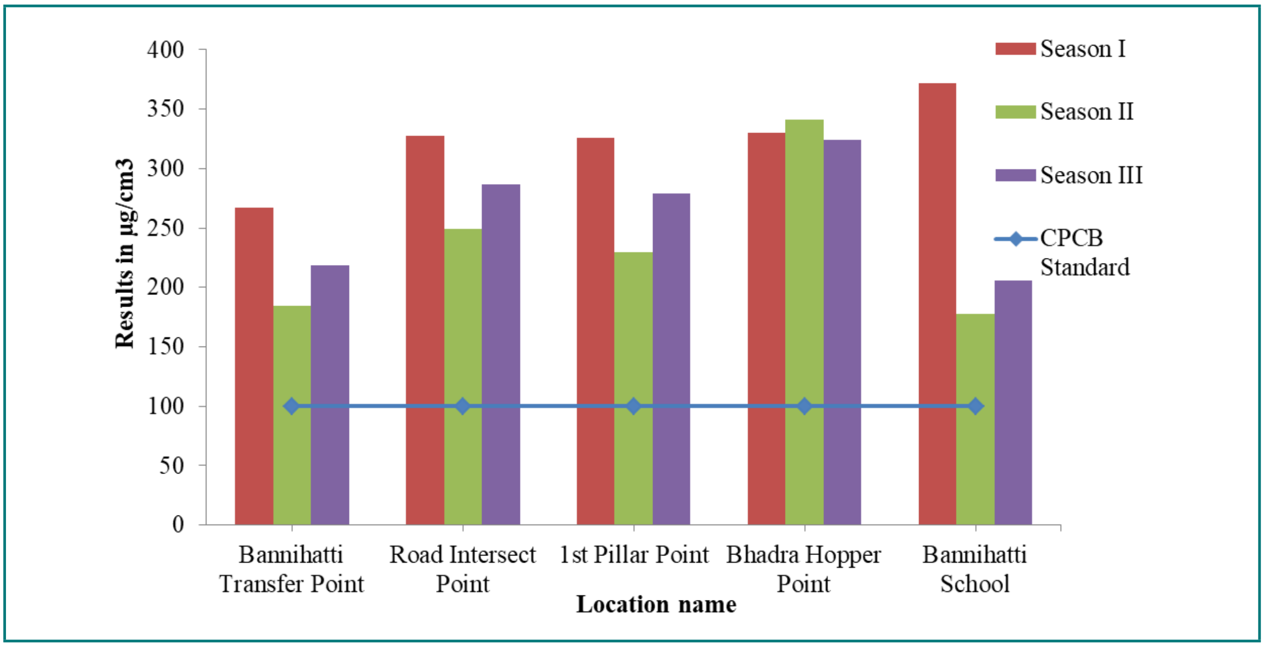
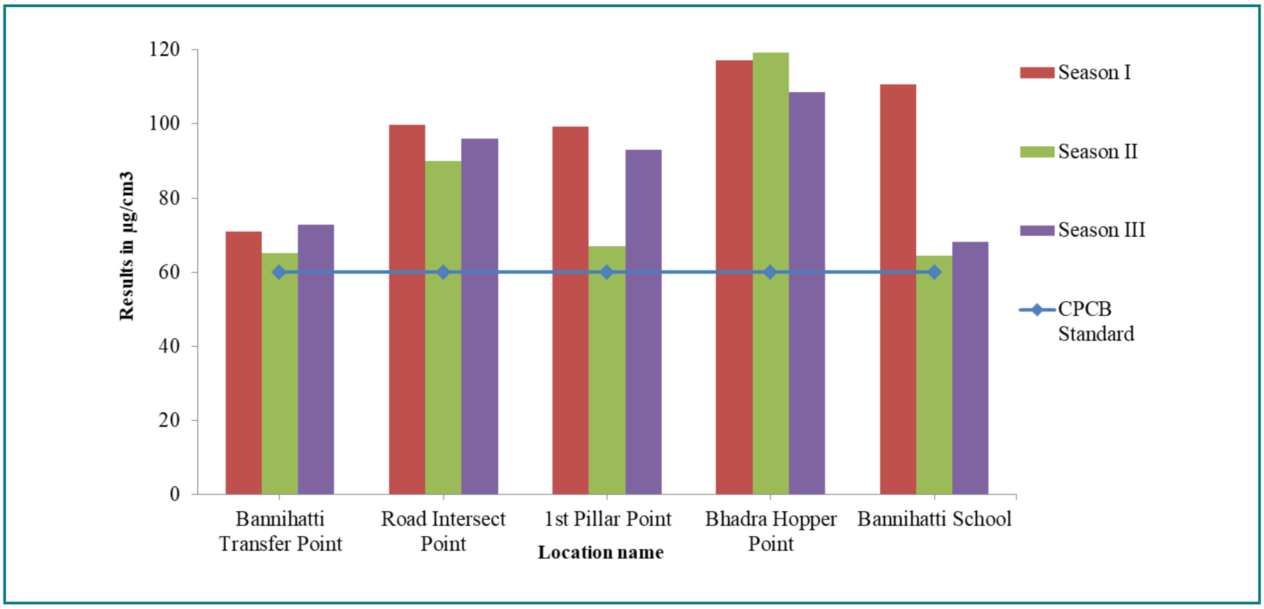


Figure 5.2 Seasonal variation of $PM_{2.5}$ – Tunga & Bhadra DHPC



Irrespective of locations and seasons, the PM_{10} and $PM_{2.5}$ concentration exceeded the National Ambient Air Quality Standards due to the movement of the trucks carrying Iron ore and mining activities (loading, unloading, crushing, drilling, blasting, etc) which have increased the dust levels and resulted in the rise of Particulate Matter. The highest Particulate Matter concentration was recorded in season I in Bannihatti school (PM_{10} - 371.8µg/m^3 and $PM_{2.5}$ - 110.7µg/m^3) whereas, the lowest Particulate Matter concentration was recorded in season II in Bannihatti school (PM_{10} - 177.6µg/m^3 and $PM_{2.5}$ - 64.4µg/m^3). The Particulate Matter concentration (PM_{10} and $PM_{2.5}$) in all the locations was higher in the season I followed by season III and season II. This is due to the increase in temperature in the season I, which in turn accelerated the concentration of Particulates in the ambient air (Ingole and Jane, 2020).

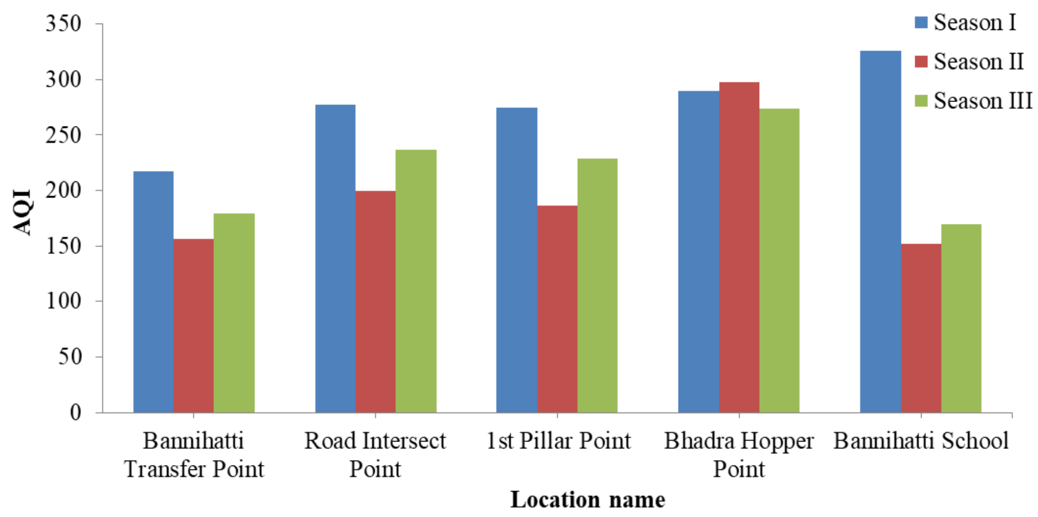
The Sulphur dioxide and Nitrogen dioxide concentration in all locations and seasons were found to be within the National Ambient Air Quality Standards. The AQI category in the study area varied from each season. Details of AQI category is given in Table 5.10.

Table 5.10 AQI catergory of Tunga & Bhadra DHPC locations

	Location Name	Season I	Season II	Season III
1	Bannihatti transfer point	Poor	Moderate	Moderate
2	Road intersect point	Poor	Moderate	Poor
3	1st pillar point	Poor	Moderate	Poor
4	Bhadra hopper point	Poor	Poor	Poor
5	Bannihatti school	Very poor	Moderate	Moderate

The Air Quality Index in the study area was better in season II and III compared to that of season I. The AQI results revealed that the ambient air quality in Bannihatti school is deteriorated and control measures needs to be taken by concerned authorities to reduce the air pollution in the area/region. The seasonal variation of AQI for Tunga & Bhadra study area is given in Figure 5.3.

Figure 5.3 Seasonal variation of AQI – Tunga & Bhadra DHPC



Human health effects: The short term exposure to Particulate Matter (PM_{10} and $PM_{2.5}$) leads to lungs, respiratory infections and aggravated asthma whereas long-term exposure results in stroke, heart disease and cancer etc. (WHO, 2021).

5.4 ToR IV

The ambient noise monitoring results are given in Table 5.11. The results are compared with CPCB standards.

Table 5.11 Ambient noise monitoring results

Location	Area/ Zone	CPCB std. dB(A)		Season I		Season II		Season III	
		Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)
Bannihatti transfer point	Industrial	75	70	62.4	62.9	62.8	63.5	65.6	64.5
Road intersect point	Residential	55	45	62.8	62.4	68.7	67	60.9	60.2
1st pillar point	Silence	50	40	63.4	65.0	69.4	74.1	73.3	69.9
Bhadra hopper point	Silence	50	40	63.3	63.4	66.6	66.7	70.6	70.4
Bannihatti school	Silence	50	40	55.5	41	64	64.1	60.5	64.9

The seasonal variation graph for day and night is given in Figure 5.4 and 5.5 respectively.

Figure 5.4 Seasonal variation of noise during day in T&B study area

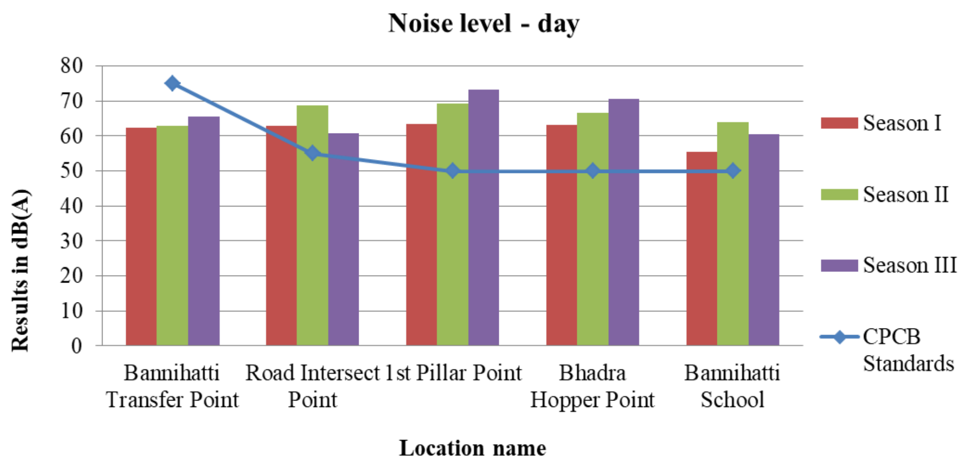
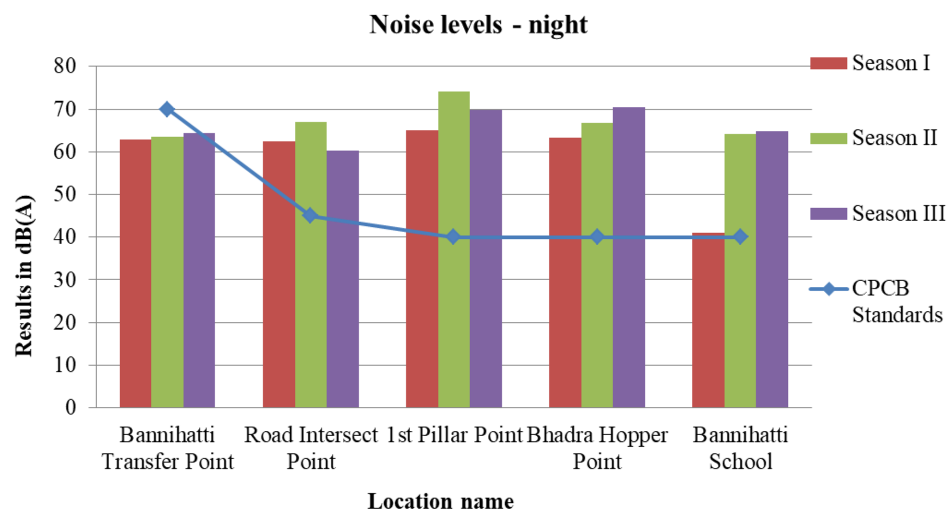


Figure 5.5 Seasonal variation of noise during night in T&B study area



Results revealed that except Bannihatti transfer point (Season I, II, and III), the noise levels in other locations and seasons exceeded the CPCB Standards both during day and night time. This is due to the movement of trucks carrying Iron ore, the use of crusher & driller machines and diesel generators, etc in the study area. During night time, the noise levels in the Bannihatti transfer point (62.9 dB(A) in season I and 63.5 dB(A) in season II), 1st pillar point (65 dB(A) in season I and 71.4 dB(A) in season II), Bhadra hopper point (63.4 dB(A) in the season I and 66.7 dB(A) in season II), and Bannihatti school (64.1 dB(A) in season II and 64.9 dB(A) in season III) were higher compared to day time due to vehicular movement in the early morning between 3 am to 6 am and natural sounds in the environment added to it. The lowest day (55.1 dB(A)) and night time (41 dB(A)) noise levels were observed in Bannihatti school in season I whereas 1st pillar point in season II and III recorded the highest day (74.1 dB(A)) and night time (69.9 dB(A)) noise levels respectively.

Results revealed that the ambient noise levels in Bannihatti school is high and control measures needs to be taken by concerned authorities to reduce the noise pollution in the area/region.

Human health effects: Noise exposure i.e., Noise levels greater than 85 dB(A) for 8 h of exposure leads to sleep disturbance, hearing impairment, hypertension, annoyance, etc. (WHO, 2022 and Chepesiuk, 2005).

5.5 ToR V

The soil results of Tunga & Bhadra sponge factory, Tunga & Bhadra road intersect, Bannihatti transfer point and Bannihatti school is given in Table 5.12, 5.13, 5.14, and 5.15 respectively.

Table 5.12 Soil quality results for Tunga & Bhadra sponge factory

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.2	1.3	1.2
2	Porosity	%	-	-	52.0	51.9	53.6
3	pH	--	<6.5	>8.5	7.2	6.3	7.7
4	Electrical Conductivity	µS/cm	<0.25	>2.25	354	569	427
5	Calcium	mg/kg	-	-	7.5	14	8.5
6	Magnesium	mg/kg	-	-	5.2	5.3	4.6
7	Chloride	mg/kg	< 0.25	>2.0	BDL	2.8	5.6
8	Nitrate	mg/kg	-	-	19.2	25.4	9.1
9	Phosphate	mg/kg	-	-	85.9	204.5	84.1
10	Sulphate	mg/kg	-	-	85.5	16.5	43.9
11	Sodium	mg/kg	-	-	5.7	5.8	7.6
12	Potassium	mg/kg	-	-	2.2	3.5	4.8
13	Water Holding Capacity	%	-	-	52.0	55.4	64.0
14	Sodium Adsorption Ratio	%	-	-	0.1	0.1	0.2
15	Exchangeable Sodium Percentage	%	-	-	0.9	0.6	1.2

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
16	Sand	%	-	-	74.0	58.5	59.5
17	Silt	%	-	-	18.5	29	30.5
18	Clay	%	-	-	7.4	12.5	10.0
19	Organic Carbon	%	0.5	0.75	0.8	0.9	0.7
20	Organic Matter	%	-	-	1.4	1.5	1.2
Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.							

Table 5.13 Soil quality results for Tunga & Bhadra road intersect

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.4	1.6	1.5
2	Porosity	%	-	-	43.8	38	43
3	pH	--	<6.5	>8.5	7.4	7.5	7.4
4	Electrical Conductivity	µS/cm	<0.25	>2.25	287	209	420
5	Calcium	mg/kg	-	-	10.9	20.2	10.6
6	Magnesium	mg/kg	-	-	4.5	4.5	2.3
7	Chloride	mg/kg	< 0.25	>2.0	5.7	5.7	3.4
8	Nitrate	mg/kg	-	-	6.2	13.1	9.9
9	Phosphate	mg/kg	-	-	32.2	38.7	8.5
10	Sulphate	mg/kg	-	-	24.5	17.7	74.0
11	Sodium	mg/kg	-	-	2.6	1.4	0.09
12	Potassium	mg/kg	-	-	5.2	4.4	0.5
13	Water Holding Capacity	%	-	-	58.4	45.5	74.0
14	Sodium Adsorption Ratio	%	-	-	0.07	0.03	0.09
15	Exchangeable SodiumPercentage	%	-	-	0.3	0.1	0.5
16	Sand	%	-	-	66.6	64	63.5
17	Silt	%	-	-	23.8	32	31.5
18	Clay	%	-	-	9.5	4	5.0
19	Organic Carbon	%	0.5	0.75	0.6	0.6	0.5
20	Organic Matter	%	-	-	1.1	1.1	0.8
Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.							

Table 5.14 Soil quality results for Bannihatti transfer point

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.3	1.4	1.3
2	Porosity	%	-	-	48.4	45.8	50.9
3	pH	--	<6.5	>8.5	7.5	7.9	7.7
4	Electrical Conductivity	µS/cm	<0.25	>2.25	282	241	418
5	Calcium	mg/kg	-	-	10.3	9.7	7.5
6	Magnesium	mg/kg	-	-	6.4	4.8	1.4
7	Chloride	mg/kg	< 0.25	>2.0	17.0	17	1.9
8	Nitrate	mg/kg	-	-	6.9	10.3	5.0
9	Phosphate	mg/kg	-	-	20.5	18.8	16.3
10	Sulphate	mg/kg	-	-	16.1	12.4	80.0
11	Sodium	mg/kg	-	-	4.2	2.9	1.9
12	Potassium	mg/kg	-	-	3.9	2.6	5.0
13	Water Holding Capacity	%	-	-	60.0	50	80.8
14	Sodium Adsorption Ratio	%	-	-	0.10	0.07	0.06
15	Exchangeable Sodium Percentage	%	-	-	0.5	0.4	0.4
16	Sand	%	-	-	68.2	73	70.0
17	Silt	%	-	-	18.2	18	19.0
18	Clay	%	-	-	13.6	9	11.0
19	Organic Carbon	%	0.5	0.75	0.1	0.1	0.1
20	Organic Matter	%	-	-	0.2	0.2	0.2
Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.							

Table 5.15 Soil quality results for Bannihatti school

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.3	1.4	1.3
2	Porosity	%	-	-	48.4	45.8	50.9
3	pH	--	<6.5	>8.5	7.5	7.9	7.7
4	Electrical Conductivity	µS/cm	<0.25	>2.25	282	241	418
5	Calcium	mg/kg	-	-	10.3	9.7	7.5
6	Magnesium	mg/kg	-	-	6.4	4.8	1.4
7	Chloride	mg/kg	< 0.25	>2.0	17.0	17	10.3
8	Nitrate	mg/kg	-	-	6.9	10.3	7.5
9	Phosphate	mg/kg	-	-	20.5	18.8	29.8
10	Sulphate	mg/kg	-	-	16.1	12.4	23.9
11	Sodium	mg/kg	-	-	4.2	2.9	1.9
12	Potassium	mg/kg	-	-	3.9	2.6	5.0

13	Water Holding Capacity	%	-	-	60.0	50	80
14	Sodium Adsorption Ratio	%	-	-	0.10	0.07	0.06
15	Exchangeable SodiumPercentage	%	-	-	0.5	0.4	0.4
16	Sand	%	-	-	68.1	73	70
17	Silt	%	-	-	18.1	18	19
18	Clay	%	-	-	13.6	9	11
19	Organic Carbon	%	0.5	0.75	0.1	0.1	0.1
20	Organic Matter	%	-	-	0.2	0.2	0.2
Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.							

In the study area, the soil pH varied from 6.9 to 7.9. The highest pH was observed in Bannihatti school (7.9) in season II. Results revealed that the pH in the study area was near neutral to alkaline. Electrical conductivity represents the measure of salts present in the soil. It was observed that electrical conductivity in the study area ranged between 166 to 587 µS/cm with the highest recorded in the Tunga & Bhadra sponge factory (587 µS/cm) in season III due to the presence of the higher amount of salts in the soil (Yaseen *et al.,* 2015).

Higher phosphate concentration in Tunga & Bhadra road intersect (97.3 mg/kg) in season III is attributed to anthropogenic activities like fertilizers application, discharge of domestic and industrial wastewater, etc to the soil whereas higher sulphate concentration in Tunga & Bhadra sponge factory (155.4 mg/kg) in season III is due to the weathering of sedimentary rocks (Patil *et al.,* 2014). Organic carbon of less than 0.75% in the study area revealed the absence of good fertile soil in the area (Ghosh *et al.,* 1983 and Yaseen *et al.,* 2015).

The Hydrological Soil Group classification showed that the soil present in the study area is silt or loam.

5.6 ToR VI

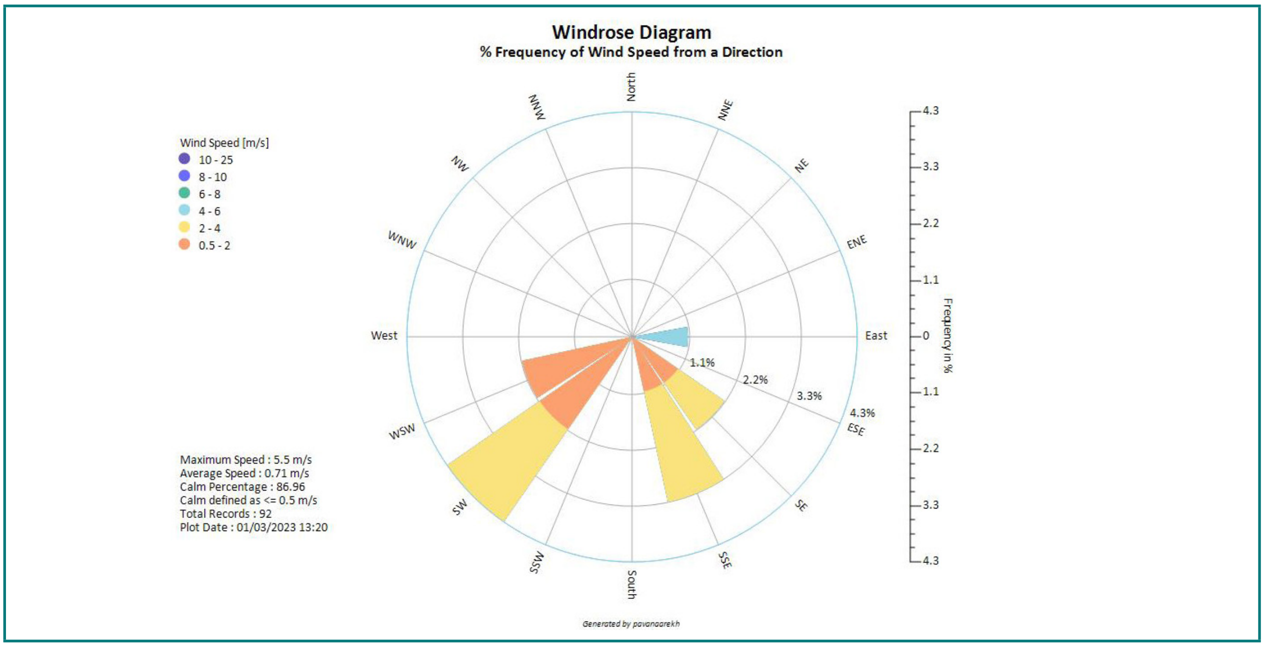
The wind rose plot and details of meterological condition for season I are given in Table 5.16.

Table 5.16 Season I meteorological data

Temperature (°C)		Total Rainfall (mm)	Humidity$_{avg}$ (%)	Wind speed$_{avg}$ (m/s)	Predominant wind direction
Max$_{avg}$	Min$_{avg}$				
25.9	17.1	223	98.9	0.7	SW

During season I the predominant wind direction was found to be South West (SW), the temperature in the study area varied between 17.1°C to 25.9°C with a total rainfall of 223 mm. The windrose plot for season I is given in Figure 5.6.

Figure 5.6 Windrose plot for season I



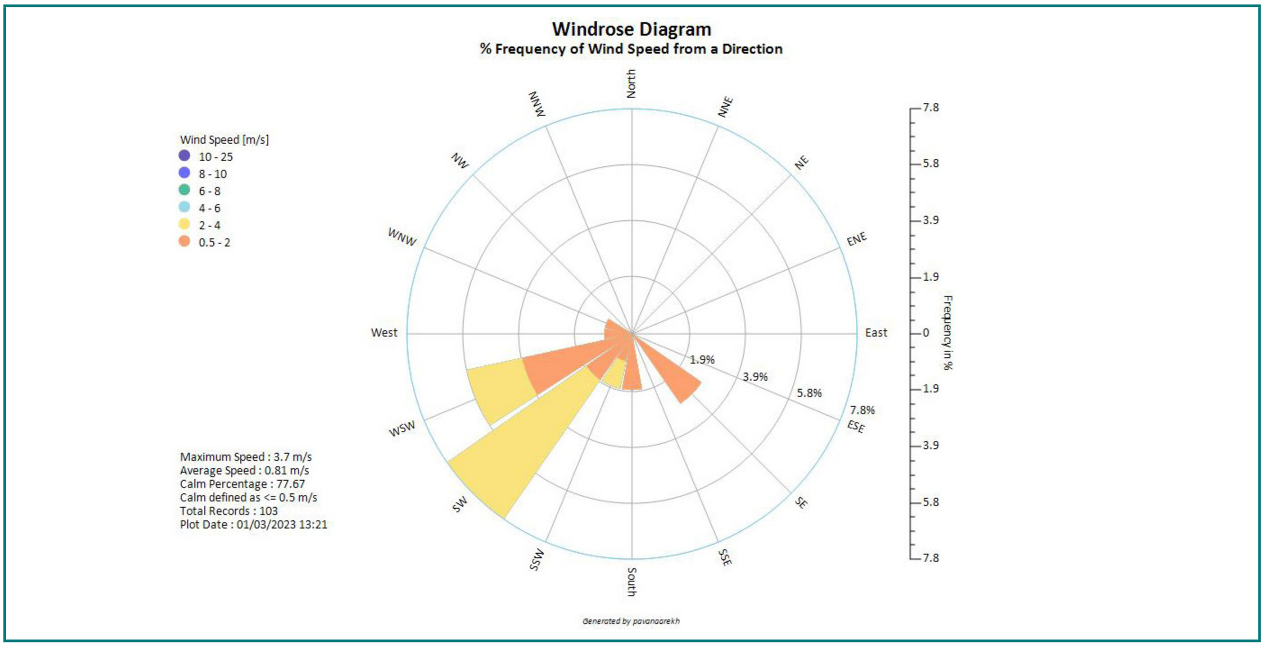
The wind rose plot and details of meterological condition for season II are given in Table 5.17.

Table 5.17 Season II meteorological data

Temperature (°C)		Total Rainfall (mm)	Humidity$_{avg}$ (%)	Wind speed$_{avg}$ (m/s)	Predominant wind direction
Max$_{avg}$	Min$_{avg}$				
26.2	16.3	111.5	96.1	0.8	SW

During season II the predominant wind direction was found to be South West (SW), the temperature in the study area varied between 16.3°C to 26.2°C with a total rainfall of 111.5 mm. The windrose plot for season I is given in Figure 5.7.

Figure 5.7 Windrose plot season II



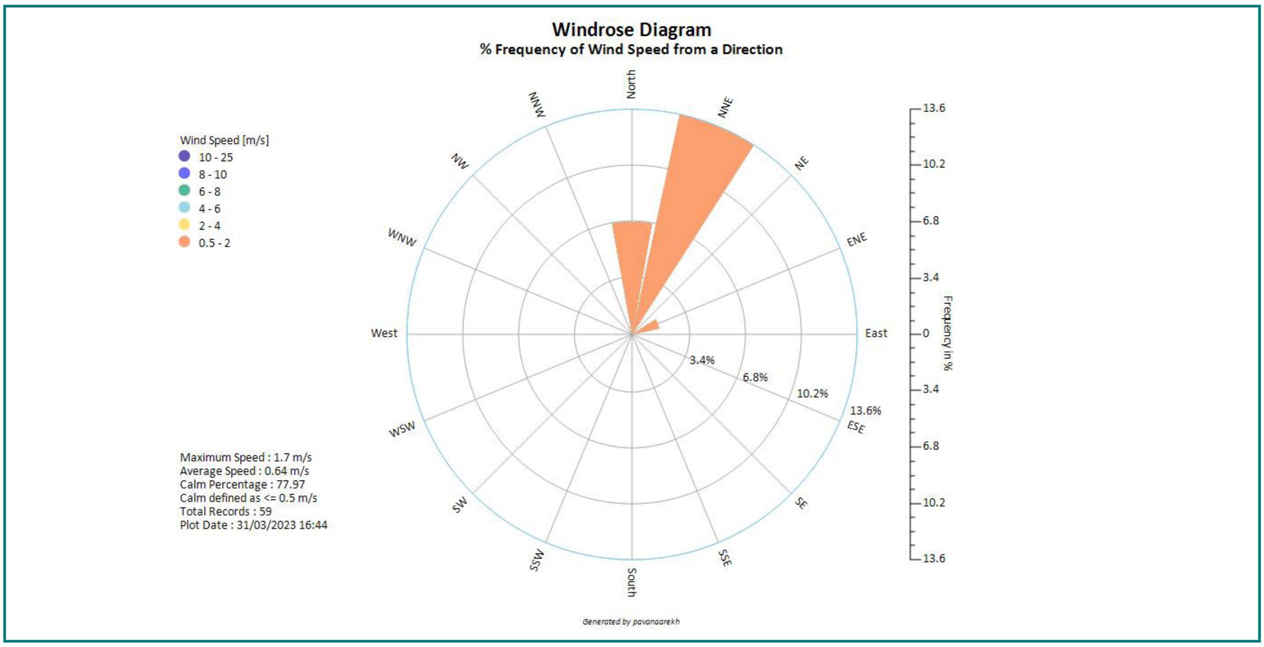
The wind rose plot and details of meterological condition for season III are given in Table 5.18.

Table 5.18 Season III meteorological data

Temperature (°C)		Total Rainfall (mm)	Humidity$_{avg}$ (%)	Wind speed$_{avg}$ (m/s)	Predominant wind direction
Max$_{avg}$	Min$_{avg}$				
27.3	14.5	7.5	84.9	0.6	NNE

During season III the predominant wind direction was found to be North North East (NNE), the temperature in the study area varied between 14.5°C to 27.3°C with a total rainfall of 7.5 mm. The windrose plot for season III is given in Figure 5.8.

Figure 5.8 Windrose plot season II



6 Rama DHPC

Rama DHPC is proposed but construction is not initiated yet. To understand the baseline condition of the study area, all the attributes given in Terms of References were assessed and the results are as follows.

6.1 ToR I

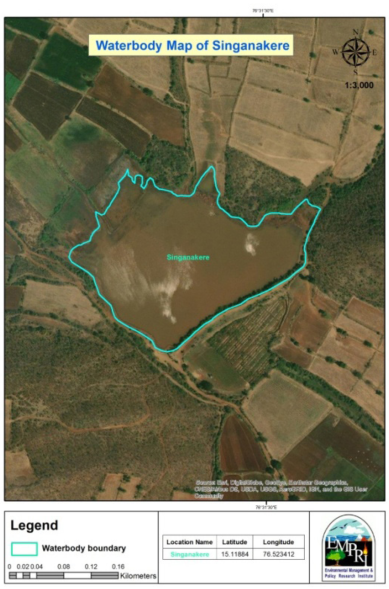
Water bodies were identified within 1 km area on either side of the DHPC as per ToRs through satellite imageries and ground truth verification was done for the same. Through field studies four active waterbodies were identified in the study area, details of the waterbody are given in Table 6.1.

Table 6.1 List of waterbodies inventorised

	Water body name	Distance (Km)	Remarks	GPS Coordinates	
				Latitude	Longitude
1	Ramgad Kunte	0.9	Seasonal	15.124177 N	76.459699 E
2	Chinnapankola	0.6	Perennial	15.119512 N	76.486171 E
3	Singanakere	0.8	Perennial	15.106779 N	76.510523 E
4	Kolifarm Lake	0.9	Seasonal	15.121022 N	76.524171 E

In Rama DHPC study area, four water bodies were found out of these Ramgad Kunte and Kolifarm Lake are seasonal while Chinnapankola and Singanakere are perennial. Google earth imagery of the water body is given in Figure 6.1.

Figure 6.1 Google earth imageries of water bodies inventorised in Rama DHPC



- **Singanakere** is a lake present in the premise of Doulatpura village of Ramanamalai block.
- The lake is spread across the area of 5.39 Ha.
- Singanakere is located 930 m away from the proposed pipe conveyor of Rama mine.

- **Ramgad kunte** is a seasonal body situated in the cavity present between Ramgad village and Ramanamalai block forest.
- It covers an area of 0.22 Ha and it is 949 m away from the proposed conveyor.

- **Kolifarm Lake** is a small pool of water located amidst the corn farms of Ramanamalai block.
- This is a seasonal water body either filled by rainfall or agricultural runoff.
- It is spread across an area of 0.31 ha.

It is 750 m away from the proposed pipe conveyor of Rama mine.

- **Chinnapankola** is a perennial lake located in the premise of Sushilanagar of Ramanamalai block.
- The lake is spread across an area of 0.39 ha.

The lake is 792 m away from the proposed pipe conveyor of Rama mine.

6.2 ToR II

6.2.1 Surface water

The results are compared with designated water quality criteria given by CPCB. The surface water results for Ramgad kunte is given in Table 6.2.

Table 6.2 Ramgad kunte - surface water results

	Parameters	Units	Water Quality Criteria					Season I	Season II	Season III
			A	B	C	D	E			
1	pH at 25°C	-	6.5 – 8.5				6 – 8.5	7.7	8.1	8.3
2	Odour	-	-	-	-	-	-	Odourless		
3	Colour	Hazen	-	10	300	300	-	1	1	4
4	TDS	mg/L	500	-	1500	-	2100	70	107	106
5	Chloride	mg/L	250	-	600	-	600	10.0	14.9	45
6	Sulphate	mg/L	400	-	400	-	1000	4.4	18.7	11.9

	Parameters	Units	Water Quality Criteria					Season I	Season II	Season III
			A	B	C	D	E			
7	Fluoride	mg/L	-	-	-	-	-	0.3	BDL	0.05
8	Boron	mg/L	-	-	-	-	<2	0.2	0.11	0.12
9	Sodium	mg/L	-	-	-	-	-	3.6	BDL	BDL
10	Iron	mg/L	-	-	-	-	-	1.6	2.1	3.3
11	Oil & Grease	mg/L	-	-	-	-	-	2.4	0.3	2.2
12	TSS	mg/L	-	-	-	-	-	120	10	23
13	TVS	mg/L	-	-	-	-	-	17	0.1	0.1
14	DO	mg/L	≥6	≥5	≥4	≥4	-	3.9	6.4	4.9
15	COD	mg/L	-	-	-	-	-	45.9	28	24
16	BOD*	mg/L	≤2	≤3	≤3	-	-	3.6	3.8	BDL
17	Sulphide	mg/L	-	-	-	-	-	BDL	BDL	BDL
18	RSC	mg/L	-	-	-	-	-	BDL	0.1	1.7
19	Phosphate	mg/L	-	-	-	-	-	1.4	1	1.4
20	Total coliform	MPN/ 100mL	≤50	≤500	≤5000	-	-	33	17	2
21	Faecal coliform		-	-	-	-	-	8	<1.8	<1.8
Water quality criteria as per CPCB classification								**D**	**D**	**C**

Note: A - Drinking water source without conventional treatment but after disinfection
B - Outdoor bathing (Organised)
C - Drinking water source after conventional treatment and disinfection
D - Propagation of wild life and fisheries
E - Irrigation, industrial cooling, controlled waste disposal
BDL-Below Detection Limit, MPN- Most Probable Number, mg/L- Milligram per Litre
*3 days @ 27°C

The pH value in the study area varied from 7.7 to 8.3, which indicates that water of Ramgad kunte ranged from neutral in season I to alkaline in season II and III. The DO values ranged between 3.9 mg/L to 6.4 mg/L, the DO levels less than 3-4 mg/L leads to suffocation and death of fish. Generally, the DO of healthy water should be 6.5 to 8 mg/L; this indicates that the lake water quality has varied in all seasons. However, no adverse impact is anticipated on aquatic life (https://www.enr.gov.nt.ca/sites/enr/files/dissolved_oxygen.pdf).

Though all the values are well within the CPCB standards due to variation in the results BOD and DO the water quality category has varied from each season. This indicates that the lake water cannot be directly used for drinking water purpose but can be used for irrigation and industrial use.

The surface water results for Chinnapanakola are given in Table 6.3.

Table 6.3 Chinnapanakola - surface water results

	Parameters	Units	Water Quality Criteria					Season I	Season II	Season III
			A	B	C	D	E			
1	pH at 25°C	-	6.5 – 8.5				6 – 8.5	8.0	8.0	8.1
2	Odour	-	-	-	-	-	-	Odourless		
3	Colour	Hazen	-	10	300	300	-	1	5	2
4	TDS	mg/L	500	-	1500	-	2100	196	502	329
5	Chloride	mg/L	250	-	600	-	600	35.0	39.9	60
6	Sulphate	mg/L	400	-	400	-	1000	28.2	24.3	30.1
7	Fluoride	mg/L	-	-	-	-	-	BDL	BDL	BDL
8	Boron	mg/L	-	-	-	-	<2	0.1	0.02	BDL
9	Sodium	mg/L	-	-	-	-	-	33.2	48	8.8
10	Iron	mg/L	-	-	-	-	-	8.9	1	1.9
11	Oil & Grease	mg/L	-	-	-	-	-	1.5	1.7	0.3
12	TSS	mg/L	-	-	-	-	-	667	15	17
13	TVS	mg/L	-	-	-	-	-	20	4.5	0.3
14	DO	mg/L	≥6	≥5	≥4	≥4	-	6.2	4.7	4.3
15	COD	mg/L	-	-	-	-	-	15.3	24	28
16	BOD	mg/L	≤2	≤3	≤3	-	-	BDL	1.4	BDL
17	Sulphide	mg/L	-	-	-	-	-	BDL	BDL	BDL
18	RSC	mg/L	-	-	-	-	-	BDL	BDL	BDL
19	Phosphate	mg/L	-	-	-	-	-	2.9	0.3	0.6
20	Total coliform	MPN/ 100mL	≤50	≤500	≤5000	-	-	49	23	23
21	Faecal coliform		-	-	-	-	-	4	2	7.8
	Water quality criteria as per CPCB classification							**A**	**C**	**C**

Note: A - Drinking water source without conventional treatment but after disinfection
B - Outdoor bathing (Organised)
C - Drinking water source after conventional treatment and disinfection
D - Propagation of wild life and fisheries
E - Irrigation, industrial cooling, controlled waste disposal
BDL-Below Detection Limit, MPN- Most Probable Number, mg/L- Milligram per Litre
*3 days @ 27°C

The pH value in the study area varied from 8.0 to 8.1, which indicates that water is alkaline. The DO values ranged between 4.3 mg/L to 6.2 mg/L, the DO levels less than 3-4 mg/L leads to suffocation and death of fish. Generally, the DO of healthy water should be 6.5 to 8 mg/L; this indicates that the lake water quality is suitable for aquatic life. (https://www.enr.gov.nt.ca/sites/enr/files/dissolved_oxygen.pdf). Though all the values are well within the CPCB standards due to variation in the results BOD and DO the water quality category has varied from each season. This indicates that the lake water cannot be directly used for drinking water purpose but with conventional resatment and disinfection can be a drinking wate source, and currently can be used for irrigation purpose.

The surface water results for Siganakere are given in Table 6.4.

Table 6.4 Singanakere - surface water results

	Parameters	Units	Water Quality Criteria					Season I	Season II	Season III
			A	B	C	D	E			
1	pH at 25°C	-	6.5 – 8.5				6 – 8.5	8.0	8.3	8.4
2	Odour	-	-	-	-	-	-	Odourless		
3	Colour	Hazen	-	10	300	300	-	1	2	2
4	TDS	mg/L	500	-	1500	-	2100	283	286	208
5	Chloride	mg/L	250	-	600	-	600	120	129.9	115
6	Sulphate	mg/L	400	-	400	-	1000	32.5	10.1	34.9
7	Fluoride	mg/L	-	-	-	-	-	0.09	BDL	BDL
8	Boron	mg/L	-	-	-	-	<2	0.1	0.07	BDL
9	Sodium	mg/L	-	-	-	-	-	61.2	28.4	7.6
10	Iron	mg/L	-	-	-	-	-	5.1	3.6	1.1
11	Oil & Grease	mg/L	-	-	-	-	-	15.4	1.4	1.1
12	TSS	mg/L	-	-	-	-	-	812	23	18
13	TVS	mg/L	-	-	-	-	-	21	0.1	0.3
14	DO	mg/L	≥6	≥5	≥4	≥4	-	5.6	4.2	4.7
15	COD	mg/L	-	-	-	-	-	26.7	16	12
16	BOD	mg/L	≤2	≤3	≤3	-	-	1.4	BDL	2.4
17	Sulphide	mg/L	-	-	-	-	-	BDL	BDL	BDL
18	RSC	mg/L	-	-	-	-	-	BDL	BDL	BDL
19	Phosphate	mg/L	-	-	-	-	-	1.2	0.7	0.8
20	Total coliform	MPN/ 100mL	≤50	≤500	≤5000	-	-	70	4.5	33
21	Faecal coliform		-	-	-	-	-	14	<1.8	7.8
Water quality criteria as per CPCB classification								**B**	**C**	**C**

Note: A - Drinking water source without conventional treatment but after disinfection
B - Outdoor bathing (Organised)
C - Drinking water source after conventional treatment and disinfection
D - Propagation of wild life and fisheries
E - Irrigation, industrial cooling, controlled waste disposal
BDL-Below Detection Limit, MPN- Most Probable Number, mg/L- Milligram per Litre
*3 days @ 27°C

The pH value in the study area varied from 8.0 to 8.4, which indicates that the water is alkaline. The DO values ranged between 4.2 mg/L to 5.6 mg/L, the DO levels less than 3-4 mg/L leads to suffocation and death of fish. Generally, the DO of healthy water should be 6.5 to 8 mg/L; this indicates that the lake water quality is suitable for aquatic life, but the further deterioration of DO levels may affect the aquatic life. (https://www.enr.gov.nt.ca/sites/enr/files/dissolved_oxygen.pdf). Though all the values are well within the CPCB standards due to variation in the results BOD and DO the water quality category has varied from each season. This indicates that the lake water cannot be directly used for drinking water purpose but with conventional treatment and disinfection can be used as drinking water source, and currently it can be used for irrigation and industrial use.

The surface water results for Koliform Lake are given in Table 6.5.

Table 6.5 Koliform Lake- surface water results

	Parameters	Units	Water Quality Criteria					Season I	Season II	Season III
			A	B	C	D	E			
1	pH at 25°C	-	6.5 – 8.5				6 – 8.5	7.9	8.1	8.5
2	Odour	-	-	-	-	-	-	Odourless		
3	Colour	Hazen	-	10	300	300	-	1	2	2
4	TDS	mg/L	500	-	1500	-	2100	122	402	302
5	Chloride	mg/L	250	-	600	-	600	15	24.9	55
6	Sulphate	mg/L	400	-	400	-	1000	14.5	3.8	21.0
7	Fluoride	mg/L	-	-	-	-	-	BDL	0.03	BDL
8	Boron	mg/L	-	-	-	-	<2	0.06	0.01	BDL
9	Sodium	mg/L	-	-	-	-	-	13.6	60	14.8
10	Iron	mg/L	-	-	-	-	-	17.3	1	2.9
11	Oil & Grease	mg/L	-	-	-	-	-	0.9	1.6	0.5
12	TSS	mg/L	-	-	-	-	-	342	21	15
13	TVS	mg/L	-	-	-	-	-	11	0.2	0.2
14	DO	mg/L	≥6	≥5	≥4	≥4	-	5.1	5.3	4.0
15	COD	mg/L	-	-	-	-	-	38.2	12	20
16	BOD	mg/L	≤2	≤3	≤3	-	-	2.4	BDL	3.2
17	Sulphide	mg/L	-	-	-	-	-	BDL	BDL	BDL
18	RSC	mg/L	-	-	-	-	-	0.21	0.2	1.2
19	Phosphate	mg/L	-	-	-	-	-	8.8	0.3	0.9
20	Total coliform	MPN/ 100mL	≤50	≤500	≤5000	-	-	49	23	49
21	Faecal coliform		-	-	-	-	-	13	<1.8	4.5
Water quality criteria as per CPCB classification								**B**	**B**	**D**

Note: A - Drinking water source without conventional treatment but after disinfection
B - Outdoor bathing (Organised)
C - Drinking water source after conventional treatment and disinfection
D - Propagation of wild life and fisheries
E - Irrigation, industrial cooling, controlled waste disposal
BDL-Below Detection Limit, MPN- Most Probable Number, mg/L- Milligram per Litre
*3 days @ 27°C

The pH value in the study area varied from 7.9 to 8.5, which indicates that the pH of water varies from neutral to alkaline. The DO values ranged between 4.0 mg/L to 5.1 mg/L, the DO levels less than 3-4 mg/L leads to suffocation and death of fish. Generally, the DO of healthy water should be 6.5 to 8 mg/L; this indicates that the lake water quality is suitable for aquatic life, but the further deterioration of DO levels may affect the aquatic life. (https://www.enr.gov.nt.ca/sites/enr/files/dissolved_oxygen.pdf). Though all the values are well within the CPCB standards due to variation in the results BOD and DO the water quality category has varied from each season. This indicates that the lake water cannot be directly used for drinking water purpose but can be used for irrigation and industrial use.

6.2.2 Groundwater

The results are compared with IS 10500:2012 drinking water quality standards. The results of groundwater for Ramgad Tayamma temple is given in Table 6.6.

Table 6.6 Ramgad- Tayamma temple groundwater results

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5 - 8.5	NR	7.1	6.3	6.5
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	270	212	259
5	Chloride	mg/L	250	1000	28.0	34.9	60
6	Sulphate	mg/L	200	400	5.5	16.3	16.6
7	Fluoride	mg/L	1	1.5	0.07	0.01	BDL
8	Boron	mg/L	0.5	1	0.1	BDL	BDL
9	Calcium	mg/L	75	200	32.1	52.9	32.1
10	Sodium	mg/L	--		11.2	10.8	BDL
11	Iron	mg/L	0.3	NR	0.9	0.9	1.6
12	Turbidity	mg/L	1	5	5.9	1	4.2
13	Total Hardness	mg/L	200	600	492	176	152
14	Magnesium	mg/L	30	100	14.6	10.7	17.5
15	Nitrate	mg/L	45	NR	0.9	1.8	BDL
16	Total Alkalinity	mg/L	200	600	140	260	280
17	Potassium	mg/L	--		8.0	8.4	7.6
18	Copper	mg/L	0.05	1.5	BDL	0.03	0.05
19	Manganese	mg/L	0.1	0.3	2.8	2.95	4.4
20	Zinc	mg/L	5	15	BDL	0.09	2.7
21	Cadmium	mg/L	0.003	NR	BDL	0.04	BDL
22	Lead	mg/L	0.01	NR	0.07	0.2	BDL
23	Total Chromium	mg/L	0.05	NR	0.1	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	BDL	0.4	0.057
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	0.002	BDL	BDL
28	Total Coliform	MPN/ 100mL	Nil		<1.8	130	2
				WQI	**E**	**E**	**E**

Result revealed that Total hardness (492 mg/L) was beyond the acceptable limit in season I due to the presence of Calcium and Magnesium ions (Suresh and Kottureshwara, 2009). Total alkalinity was beyond the acceptable limit in season II (260 mg/L) and season III (280 mg/L) due to the presence of a higher concentration of Carbonate and Bicarbonate ions (Thotappaiah *et al.*, 2019). Aluminium (0.4 mg/L) concentration in season I, Lead (0.07 mg/L), Total Chromium (0.1 mg/L) concentration in season II and Iron, Manganese concentration in all the seasons exceeded the permissible limit. Higher heavy metals concentration is due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009., Su *et al.*, 2014 and Karunanidhi *et al.*, 2021). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

The results of groundwater for Radhanagar are given in Table 6.7.

Table 6.7 Radhanagar groundwater results

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5 - 8.5	NR	7.6	7	7.1
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	1095	653	891
5	Chloride	mg/L	250	1000	112	124.9	135
6	Sulphate	mg/L	200	400	17.3	26.4	46.1
7	Fluoride	mg/L	1	1.5	BDL	0.1	BDL
8	Boron	mg/L	0.5	1	0.1	0.03	0.05
9	Calcium	mg/L	75	200	256.5	139.5	147.5
10	Sodium	mg/L	--		51.2	55.6	11.6
11	Iron	mg/L	0.3	NR	0.06	0.1	0.1
12	Turbidity	mg/L	1	5	2.7	1.2	1.2
13	Total Hardness	mg/L	200	600	588	508	580
14	Magnesium	mg/L	30	100	12.6	38.9	51.5
15	Nitrate	mg/L	45	NR	8.9	8.1	8.3
16	Total Alkalinity	mg/L	200	600	540	470	472
17	Potassium	mg/L	--		2.8	2	2.8
18	Copper	mg/L	0.05	1.5	BDL	BDL	0.05
19	Manganese	mg/L	0.1	0.3	0.08	0.01	0.1
20	Zinc	mg/L	5	15	0.06	0.02	0.1
21	Cadmium	mg/L	0.003	NR	BDL	0.04	BDL
22	Lead	mg/L	0.01	NR	BDL	0.2	0.06
23	Total Chromium	mg/L	0.05	NR	0.1	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	0.013	BDL	0.059
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	BDL	BDL	0.004
28	Total Coliform	MPN/ 100mL	Nil		23	4.5	220
				WQI	**C**	**A**	**C**

Result showed that Total Dissolved Solids, Total hardness and Total alkalinity were beyond the acceptable limit in all the seasons with highest Total Dissolved Solids (1095 mg/L), Total hardness (588 mg/L) and Total alkalinity (540 mg/L) recorded in season I. Higher Total Dissolved Solids are due to the presence of higher content of Bicarbonate, Calcium, Magnesium, Chloride, Sulphate ions, etc. in groundwater (Nawlakhe *et al.*, 1995 & Singh and Somashekhar, 2015). Higher hardness is due to the presence of Calcium and Magnesium ions (Suresh and Kottureshwara, 2009) whereas the presence of a higher concentration of Carbonate and Bicarbonate ions resulted in high alkalinity (Thotappaiah *et al.*, 2019). Lead (0.2 mg/L) concentration in season I, Total Chromium (0.1 mg/L) concentration in season II and Aluminium concentration in season II and III exceeded the permissible limit. Higher heavy metals concentration is due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009., Su *et al.*, 2014 and Karunanidhi *et al.*, 2021). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

The results of groundwater for Sushilnagar school are given in Table 6.8.

Table 6.8 Sushilnagar school groundwater results

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5 - 8.5	NR	7.1	6.8	7.3
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	1114	1180	1006
5	Chloride	mg/L	250	1000	373.8	384.8	234.9
6	Sulphate	mg/L	200	400	92.5	97.7	94.1
7	Fluoride	mg/L	1	1.5	0.4	0.2	BDL
8	Boron	mg/L	0.5	1	0.1	0.12	0.09
9	Calcium	mg/L	75	200	246.9	338.3	283.8
10	Sodium	mg/L	--		55.2	60.4	13.6
11	Iron	mg/L	0.3	NR	0.1	0.8	0.8
12	Turbidity	mg/L	1	5	0.2	0.8	1.5
13	Total Hardness	mg/L	200	600	1000	1004	1124
14	Magnesium	mg/L	30	100	93.3	38.9	101
15	Nitrate	mg/L	45	NR	9.0	8.4	8.7
16	Total Alkalinity	mg/L	200	600	500	390	462
17	Potassium	mg/L	--		6.0	4.8	6
18	Copper	mg/L	0.05	1.5	BDL	BDL	0.08
19	Manganese	mg/L	0.1	0.3	BDL	BDL	0.07
20	Zinc	mg/L	5	15	BDL	BDL	BDL
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL
22	Lead	mg/L	0.01	NR	BDL	0.3	0.18
23	Total Chromium	mg/L	0.05	NR	0.02	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	0.009	0.1	0.021
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	0.006	BDL	0.022
28	Total Coliform	MPN/ 100mL	Nil		1600	130	>1600
				WQI	**B**	**C**	**E**

Result revealed that Total Dissolved Solids, Total hardness, and Total alkalinity were beyond the acceptable limit in all the seasons. Higher Total Dissolved Solids are due to the presence of higher content of Bicarbonate, Calcium, Magnesium, Chloride, Sulphate ions, etc. in groundwater (Nawlakhe *et al.*, 1995 & Singh and Somashekhar, 2015). Higher hardness is due to the presence of Calcium and Magnesium ions (Suresh and Kottureshwara, 2009) whereas the presence of a higher concentration of Carbonate and Bicarbonate ions resulted in high alkalinity (Thotappaiah *et al.*, 2019). Higher Chloride content in season I (373.8 mg/L) and season II (384.8 mg/L) is attributed to the usage of inorganic fertilizers and natural geochemical activities (Weathering of rocks, volcanic activity, etc) in the study area (Sarala and Babu, 2012 & Thotappaiah *et al.*, 2019).

Lead (0.3 mg/L), Iron (0.8 mg/L) concentration in season II, Aluminium (0.02 mg/L), Total Arsenic (0.02 mg/L) and Copper (0.08 mg/L) concentration in season III exceeded the permissible limit due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009., Su *et al.*, 2014 & Annapoorna and Janardhana, 2016). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

The results of groundwater for Doulatpura are given in Table 6.9.

Table 6.9 Doulatpura groundwater results

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
1	pH	--	6.5 - 8.5	NR	7.2	7.4	7.4
2	Odour		Agreeable		Odourless		
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	846	553	684
5	Chloride	mg/L	250	1000	98	114.9	105
6	Sulphate	mg/L	200	400	21.3	35.2	37.8
7	Fluoride	mg/L	1	1.5	0.5	0.3	BDL
8	Boron	mg/L	0.5	1	0.07	0.04	0.06
9	Calcium	mg/L	75	200	144.2	139.5	129.9
10	Sodium	mg/L	--		20.8	23.6	1.2
11	Iron	mg/L	0.3	NR	0.1	0.4	0.3
12	Turbidity	mg/L	1	5	1.0	2.5	0.7
13	Total Hardness	mg/L	200	600	484	472	468
14	Magnesium	mg/L	30	100	30.1	30.1	35
15	Nitrate	mg/L	45	NR	6.7	7.5	6.4
16	Total Alkalinity	mg/L	200	600	360	310	328
17	Potassium	mg/L	--		0.8	0.4	BDL
18	Copper	mg/L	0.05	1.5	BDL	BDL	0.06
19	Manganese	mg/L	0.1	0.3	BDL	0.01	0.08
20	Zinc	mg/L	5	15	BDL	0.02	0.1
21	Cadmium	mg/L	0.003	NR	BDL	0.04	BDL

	Particular	Units	Std. IS 10500:2012*		Season I	Season II	Season III
			AL*	PL*			
22	Lead	mg/L	0.01	NR	BDL	0.3	0.12
23	Total Chromium	mg/L	0.05	NR	0.04	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	BDL	0.1	0.111
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	BDL	BDL	0.003
28	Total Coliform	MPN/100mL	Nil		17	11	9.3
				WQI	**B**	**C**	**C**

Result showed that Total Dissolved Solids, Total hardness and Total alkalinity were beyond the acceptable limit in all the seasons with highest Total Dissolved Solids (846 mg/L), Total hardness (484 mg/L) and Total alkalinity (36s0 mg/L) recorded in season I. Higher Total Dissolved Solids are due to the presence of higher content of Bicarbonate, Calcium, Magnesium, Chloride, Sulphate ions, etc. in groundwater (Nawlakhe *et al.*, 1995 & Singh and Somashekhar, 2015). Higher hardness is due to the presence of Calcium and Magnesium ions (Suresh and Kottureshwara, 2009) whereas the presence of a higher concentration of Carbonate and Bicarbonate ions resulted in high alkalinity (Thotappaiah *et al.*, 2019). Iron (0.4 mg/L), Lead (0.3 mg/L), Cadmium (0.04 mg/L), Aluminium (0.1 mg/L) concentration in season II exceeded the permissible limit. Higher heavy metals concentration is due to natural (Weathering of rocks) or anthropogenic activities (Mining activity, fertilizer application, industrial effluent discharge, etc) in the study area (Satapathy *et al.*, 2009 and Su *et al.*, 2014). The presence of Total coliform in all seasons is due to the improper disposal of domestic wastewater in the study area (Singh *et al.*, 2019).

Human health effects: Drinking hard water causes diarrhoea (WHO, 2010) whereas consumption of excessive amount of alkaline water reduces natural acid in the stomach and leads to anxiety and irritability (Rane *et al.*, 2022). Excessive intake of drinking water containing Chloride concentration of more than 2.5 g/litre has been reported to produce hypertension (WHO, 2003). The presence of higher Iron content in human body causes liver cancer, diabetes, infertility etc. (Kumar *et al.*, 2017) whereas excess Aluminium presence results in the development of Alzheimer disease (WHO, 2003). Manganese concentration of more than 0.2 mg/L in drinking water leads to neurotoxicity (WHO, 2004).

Acute Lead intoxication causes headache, abdominal cramps, kidney damage and chronic toxicity results in tiredness, sleeplessness, irritability, joint pain etc. (WHO, 2003). Acute exposure of Copper leads to headache, vomiting etc. and long-term exposure causes nausea, abdominal pain, diarrhoea etc. (WHO, 2004). High intake of Cadmium leads to osteoporosis, kidney dysfunction etc. (WHO, 2004) whereas Chromium presence in drinking water leads to respiratory, liver, kidney injury etc. (WHO, 2020). The presence of Arsenic in drinking water leads to skin, bladder and lung cancer (WHO, 2003) whereas coliforms presence causes diarrhoea, nausea and fever in infants (WHO, 2017).

6.3 ToR III

The results are compared with NAAQ Standards. The results of ambient air for Rama hopper point is given in Table 6.10.

Table 6.10 Rama hopper point ambient air results

	CPCB Standards	Season1	Season II	Season III
PM_{10}	100	**272.7**	**219.1**	**230.2**
$PM_{2.5}$	60	**90.8**	**75.5**	**76.3**
SO_2	80	4.4	3.3	BDL
NO_2	80	14.4	10.5	8.8

The AAQM results of Rama hopper point revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards. The results of ambient air for Ramgad village are given in Table 6.11.

Table 6.11 Ramgad village ambient air results

	CPCB Standards	Season I	Season II	Season III
PM_{10}	100	**186.9**	**136**	**151.7**
$PM_{2.5}$	60	**63.9**	**45.3**	**51.1**
SO_2	80	BDL	BDL	BDL
NO_2	80	6.5	5.8	4.8

The AAQM results of Rama village revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards.

The results of ambient air for Transfer point-1 is given in Table 6.12.

Table 6.12 Transfer point-1 ambient air results

Parameter	CPCB Standards	Season1	Season II	Season III
PM_{10}	100	**378.7**	**317.4**	**344.1**
$PM_{2.5}$	60	**110.8**	**104.6**	**115.6**
SO_2	80	BDL	4.2	4
NO_2	80	6.1	12.2	12.7

The AAQM results of Transfer point - 1 revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards.

The results of ambient air for Transfer point-2 is given in Table 6.13.

Table 6.13 Transfer point – 2 ambient air results

Parameter	CPCB Standards	Season1	Season II	Season III
PM_{10}	100	**280.5**	**226.3**	**257**
$PM_{2.5}$	60	**74.4**	**78.1**	**85.9**
SO_2	80	3.8	BDL	3.1
NO_2	80	9.0	7.9	8.6

The AAQM results of Transfer point - 2 revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards.

The results of ambient air for Sushilnagar school are given in Table 6.14.

Table 6.14 Sushilnagar school – ambient air results

Parameter	CPCB Standards	Season1	Season II	Season III
PM_{10}	100	**347.2**	**270.6**	**324.3**
$PM_{2.5}$	60	**109.6**	**102.1**	**109.4**
SO_2	80	BDL	3.3	3.9
NO_2	80	9.6	10.5	11.3

The AAQM results of Sushilnagar school revealed that the PM_{10} and $PM_{2.5}$ values were beyond CPCB standards. However, SO_2 and NO_2 values were very low and well within the standards.

Overall the PM_{10} concentration in all the locations and seasons exceeded the National Ambient Air Quality Standards. Except Ramgad village (45.3 µg/m^3 in season II and 51.1 µg/m^3 in season III) the $PM_{2.5}$ concentration in the rest of the locations and seasons was beyond the National Ambient Air Quality Standards. This is due to a rise in dust levels from vehicles transporting Iron ore and as a result, the Particulate Matter concentration increased. The highest and lowest Particulate Matter concentration was recorded in the season I and season II in Transfer Point 1 (Sushilnagar) (PM_{10} - 378.7µg/m^3 and $PM_{2.5}$ - 110.8µg/m^3) and Ramgad village (PM_{10} - 136µg/m^3 and $PM_{2.5}$ - 45.3µg/m^3) respectively. The Particulate Matter concentration (PM_{10} and $PM_{2.5}$) in all the locations was higher in the season I followed by season III and season II. This is due to the increase in temperature in the season I which in turn accelerated the concentration of Particulates in the ambient air (Ingole and Jane, 2020).

The Sulphur dioxide and Nitrogen dioxide concentration in all locations and seasons were found to be within the National Ambient Air Quality Standards. The seasonal variation of PM_{10} and $PM_{2.5}$ is given in Figure 6.2 and 6.3 respectively.

Figure 6.2 Seasonal variation of PM_{10} – Rama DHPC

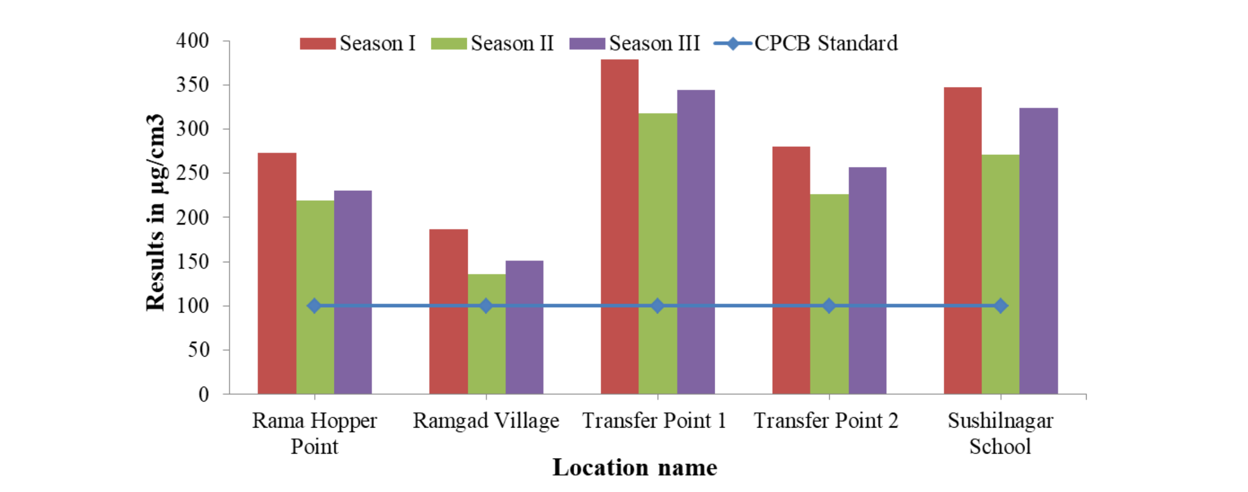
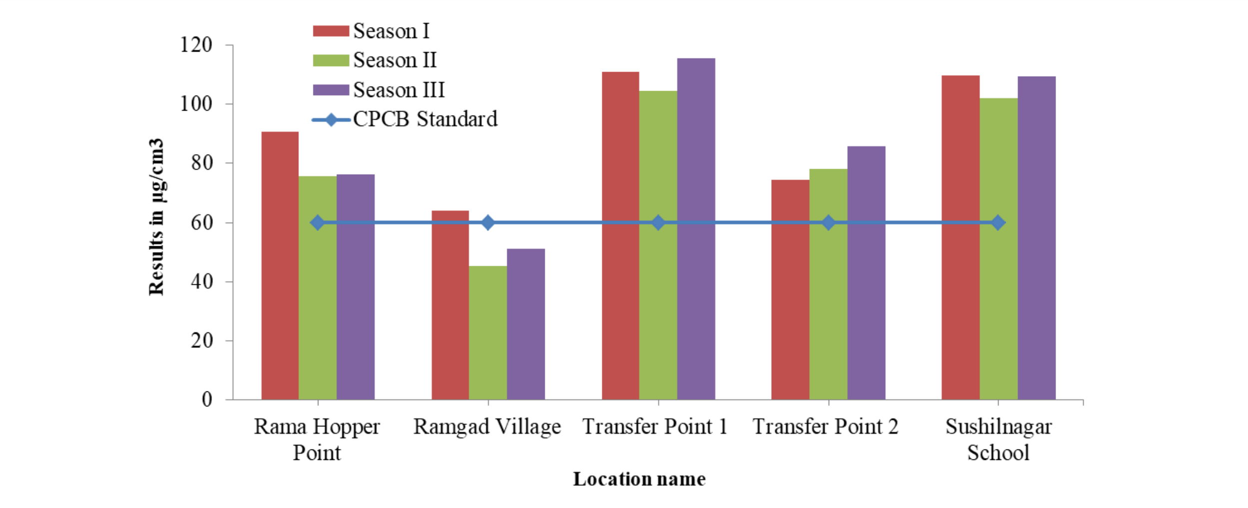


Figure 6.3 Seasonal variation of $PM_{2.5}$ – Rama DHPC



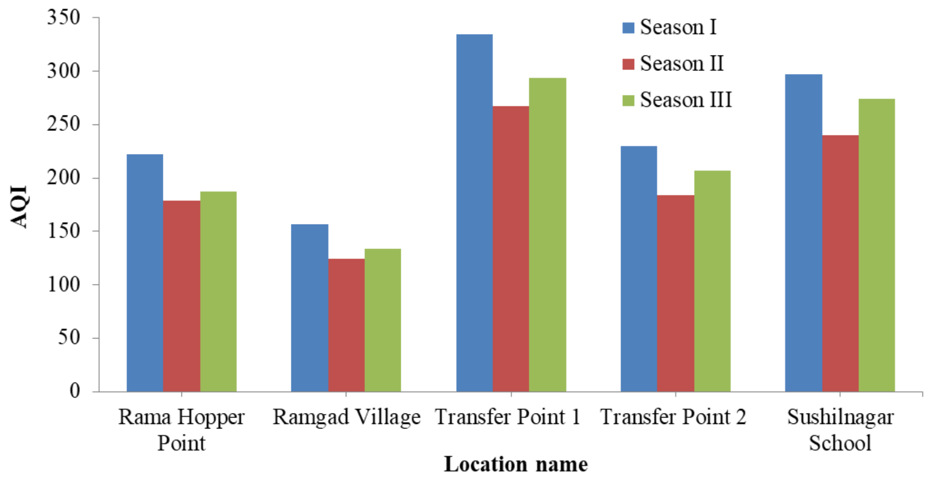
Details of AQI category is given in Table 6.15. The Air Quality Index in the study area was better in season II compared to that of the season I and season III respectively.

Table 6.15 AQI category for Rama DHPC locations

	Locations	AQI category		
		Season I	Season II	Season III
1	Rama hopper point	Poor	Moderate	Moderate
2	Ramgad village	Moderate	Moderate	Moderate
3	Transfer point - 1	Very poor	Poor	Poor
4	Transfer point - 2	Poor	Moderate	Poor
5	Sushilnagar school	Poor	Poor	Poor

AQI results revealed that the ambient air quality in Ramgad village and Sushilnagar school is moderate and poor, control measures needs to be taken by concerned authorities to reduce the air pollution in the area/region. The seasonal variation of AQI is represented graphically as shown in Figure 6.4.

Figure 6.4 Seasonal variation of AQI – Rama DHPC



Human health effects: The short term exposure to Particulate Matter (PM_{10} and $PM_{2.5}$) leads to lungs, respiratory infections and aggravated asthma whereas long-term exposure results in stroke, heart disease and cancer etc. (WHO, 2021).

6.4 ToR IV

The ambient noise monitoring results are given in Table 6.16. The results are compared with CPCB standards.

Table 6.16 Ambient noise monitoring results

Location name	Area/Zone	CPCB std. dB(A)		Season I		Season II		Season III	
		Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)
Rama hopper point	Silence	50	40	61.7	61.0	57.3	55.9	70.7	69.5
Ramgad village	Silence	50	40	66.1	68.4	81.3	89.8	64.8	63.9
Transfer point 1 (Sushilnagar)	Silence	50	40	63.1	66.3	73.6	79	63.7	65.5
Transfer point 2 (Doulatpura)	Residential	55	45	61.2	61.5	61.8	60.9	63.2	62.4
Sushilnagar school	Silence	50	40	51.9	51.9	61	61.2	76.2	76.8

Results revealed that the noise levels irrespective of locations and seasons exceeded the CPCB Standards both during day and night time. Compared to day time, higher noise levels were recorded during night time in Ramgad village (Season I and II), Transfer point 1 (Sushilnagar), and Sushilnagar school in all seasons due to the movement of trucks between 3 am to 6 am and natural sounds in environment contributed to the rise in noise levels. During season I and II, the lowest and highest noise levels were recorded in Sushilnagar School (Day time - 51.9 dB(A) and night time - 51.9 dB(A)) and Ramgad village (Day time - 81.3 dB(A) and night time - 89.8 dB(A)) respectively.

Results revealed that the ambient noise levels in Ramgad village and Sushilnagar school is high and control measures needs to be taken by concerned authorities to reduce the noise pollution in the area/region.

Figure 6.5 Seasonal variation of noise levels during day

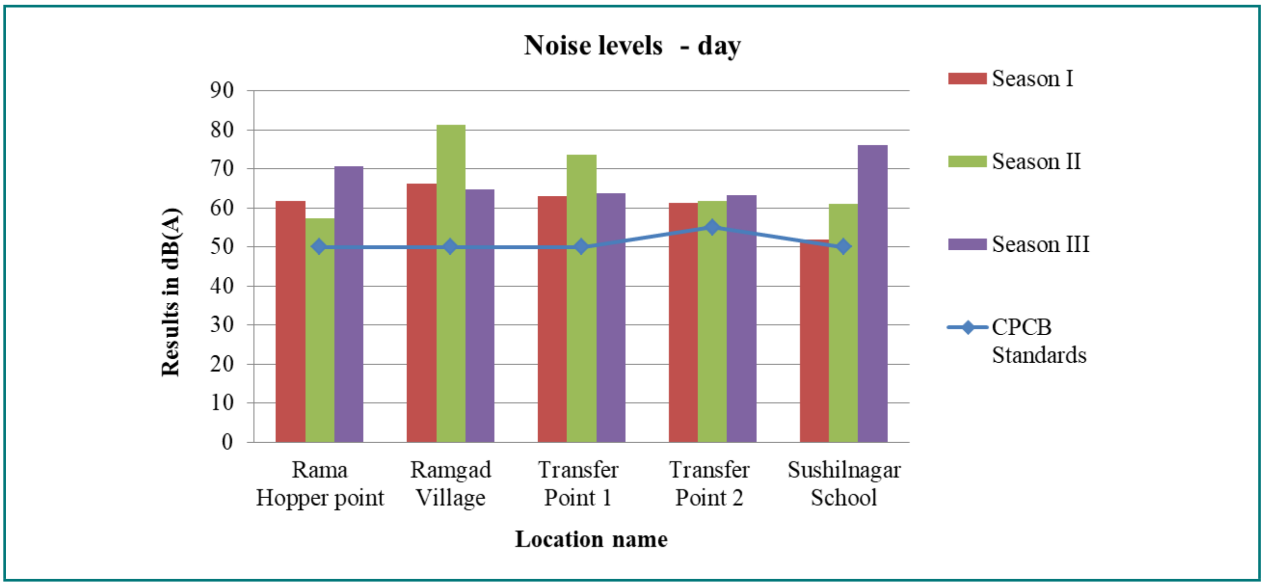
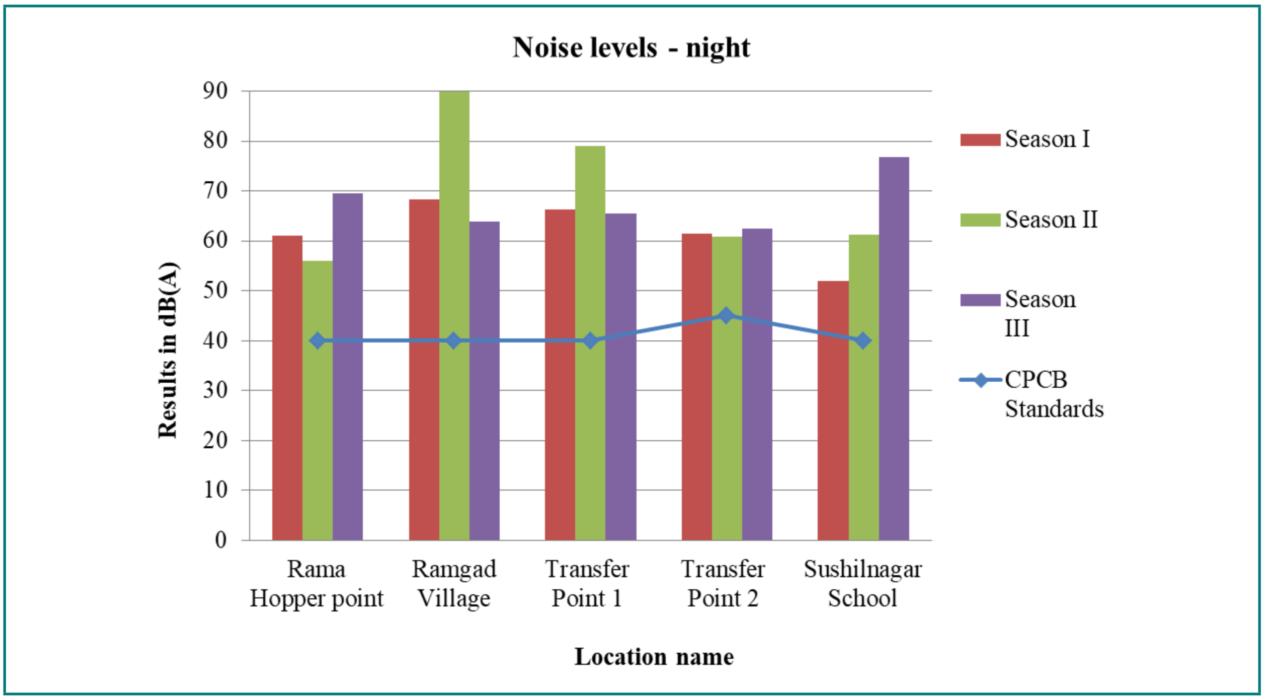


Figure 6.6 Seasonal variation of noise levels during night



Human health effects: Noise exposure i.e., Noise levels greater than 85 dB(A) for 8 h of exposure leads to sleep disturbance, hearing impairment, hypertension, annoyance, etc. (WHO, 2022 and Chepesiuk, 2005).

6.5 ToR V

The soil quality results for Ramgad Tayamma temple, Radhanagar, Sushilnagar school, and Doulatpura is given in Table 6.17, 6.18, 6.19 and 6.20 respectively.

Table 6.17 Ramgad Tayamma temple - soil analysis results

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.3	1.4	1.3
2	Porosity	%	-	-	50.3	43.9	50.9
3	pH	--	<6.5	>8.5	7.5	7.1	7.7
4	Electrical Conductivity	µS/cm	<0.25	>2.25	117	104	149
5	Calcium	mg/kg	-	-	4.3	5.3	4.0
6	Magnesium	mg/kg	-	-	0.9	1.8	1.1
7	Chloride	mg/kg	< 0.25	>2.0	42.5	5.7	5.7
8	Nitrate	mg/kg	-	-	13.6	15.0	9.0
9	Phosphate	mg/kg	-	-	50.5	49.5	57.7
10	Sulphate	mg/kg	-	-	28.5	29.2	10.2
11	Sodium	mg/kg	-	-	1.3	1.0	1.5
12	Potassium	mg/kg	-	-	5.8	5.8	8.7
13	Water Holding Capacity	%	-	-	48.8	49.0	82.0
14	Sodium Adsorption Ratio	%	-	-	0.06	0.04	0.07
15	Exchangeable Sodium Percentage	%	-	-	0.6	0.3	0.6
16	Sand	%	-	-	43.4	75.7	70.8
17	Silt	%	-	-	21.7	16.3	20.0
18	Clay	%	-	-	34.8	8.0	9.2
19	Organic Carbon	%	0.5	0.75	0.1	0.1	0.1
20	Organic Matter	%	-	-	0.2	0.2	0.2

Note: BDL- Below Detection Limit, g/cm3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.

Table 6.18 Radhanagar - soil analysis results

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.4	1.1	1
2	Porosity	%	-	-	46.7	58.5	61.8
3	pH	--	<6.5	>8.5	7.2	7.1	7.4
4	Electrical Conductivity	µS/cm	<0.25	>2.25	374	296	232
5	Calcium	mg/kg	-	-	9.6	10.3	7.0
6	Magnesium	mg/kg	-	-	6.8	8.8	3.5
7	Chloride	mg/kg	< 0.25	>2.0	51.0	11.3	14.2
8	Nitrate	mg/kg	-	-	20.2	20.3	10.3

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
9	Phosphate	mg/kg	-	-	105.4	143.5	111.5
10	Sulphate	mg/kg	-	-	20.3	12.2	17.7
11	Sodium	mg/kg	-	-	1.7	3.9	5.9
12	Potassium	mg/kg	-	-	11.4	5.4	8.4
13	Water Holding Capacity	%	-	-	61.6	59.6	80.0
14	Sodium Adsorption Ratio	%	-	-	0.04	0.09	0.18
15	Exchangeable Sodium Percentage	%	-	-	0.2	0.4	1.2
16	Sand	%	-	-	73.7	70.2	69.7
17	Silt	%	-	-	16.3	14.7	20.3
18	Clay	%	-	-	9.8	15.1	10.0
19	Organic Carbon	%	0.5	0.75	1	1	1
20	Organic Matter	%	-	-	1.8	1.8	1.8

Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.

Table 6.19 Sushilnagar school - soil analysis results

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.3	1.4	1.4
2	Porosity	%	-	-	49.1	47.2	46.8
3	pH	--	<6.5	>8.5	7.2	7.2	7.37
4	Electrical Conductivity	µS/cm	<0.25	>2.25	374.0	323	209
5	Calcium	mg/kg	-	-	8.8	14.6	13.4
6	Magnesium	mg/kg	-	-	5.1	9	1.3
7	Chloride	mg/kg	< 0.25	>2.0	8.5	8.5	11.3
8	Nitrate	mg/kg	-	-	13.0	14.3	8.3
9	Phosphate	mg/kg	-	-	26.5	35.3	36.1
10	Sulphate	mg/kg	-	-	39.6	25.8	12.7
11	Sodium	mg/kg	-	-	4.4	4.4	4.9
12	Potassium	mg/kg	-	-	3.5	2.3	4.4
13	Water Holding Capacity	%	-	-	60.8	51.2	84.0
14	Sodium Adsorption Ratio	%	-	-	0.1	0.09	0.12
15	Exchangeable Sodium Percentage	%	-	-	0.6	0.4	0.7
16	Sand	%	-	-	68.1	64	62.0
17	Silt	%	-	-	23	26.4	28.6
18	Clay	%	-	-	8.8	9.6	9.4
19	Organic Carbon	%	0.5	0.75	0.3	0.4	0.3
20	Organic Matter	%	-	-	0.5	0.7	0.5

Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.

Table 6.20 Doulatpura - soil analysis results

	Parameters	Units	Limitation		Season I	Season II	Season III
			Low	High			
1	Bulk density	g/cm^3	-	-	1.3	1.6	1.50
2	Porosity	%	-	-	49.3	38.9	43.4
3	pH	--	<6.5	>8.5	7.1	7.5	7.68
4	Electrical Conductivity	µS/cm	<0.25	>2.25	345.0	202	310
5	Calcium	mg/kg	-	-	7.0	13.4	12.6
6	Magnesium	mg/kg	-	-	4.4	9.0	2.7
7	Chloride	mg/kg	< 0.25	>2.0	5.7	5.7	8.5
8	Nitrate	mg/kg	-	-	12.5	14.2	7.5
9	Phosphate	mg/kg	-	-	60.0	64.9	91.4
10	Sulphate	mg/kg	-	-	29.7	15.6	15.1
11	Sodium	mg/kg	-	-	4.0	3.8	7.1
12	Potassium	mg/kg	-	-	5.1	2.5	5.4
13	Water Holding Capacity	%	-	-	63.2	46	56.0
14	Sodium Adsorption Ratio	%	-	-	0.1	0.08	0.18
15	Exchangeable Sodium Percentage	%	-	-	0.7	0.3	1.0
16	Sand	%	-	-	77.5	70.9	69.8
17	Silt	%	-	-	13.7	24.5	25.0
18	Clay	%	-	-	8.6	4.6	5.2
19	Organic Carbon	%	0.5	0.75	0.3	0.3	0.3
20	Organic Matter	%	-	-	0.6	0.6	0.6

Note: BDL- Below Detection Limit, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, mg/kg - Milligram per kilogram, % - Percentage.

The soil pH in the study area varied from 7.1 to 7.7. The highest pH was observed in the Ramgad - Tayamma temple (7.7) in season III. Results revealed that the pH in the study area was near neutral to alkaline. Electrical conductivity represents the measure of salts present in the soil. It was observed that electrical conductivity in the study area ranged between 104 to 374 µS/cm with the highest recorded in Radhanagar (374 µS/cm) and Sushilnagar school (374 µS/cm) in season I due to the presence of the higher amount of salts in the soil (Yaseen *et al.,* 2015).

Higher phosphate concentration in Radhanagar (111.5 mg/kg) in season III is attributed to anthropogenic activities like fertilizers application, discharge of domestic and industrial wastewater, etc to the soil whereas higher sulphate concentration in Radhanagar (105.4 mg/kg) in the season I is due to the weathering of sedimentary rocks (Patil *et al.,* 2014).

Organic carbon greater than 0.75% in Radhanagar revealed the presence of good fertile soil in the area (Ghosh *et al.,* 1983 and Yaseen *et al.,* 2015). Hydrological Soil Group classification showed that the soil present in the study area is predominantly silt or loam.

Soil alkalinity is due to excessive buildup if salts like sodium carbonate or sodium bicarbonate. Even when the land is dry with a very little rainfall the soil turns alkaline.

"*Food security at stake*" Deccan Herald (March 26, 2023)

6.6 ToR VI

The wind rose plot and details of meterological condition for season I are given in Table 6.21.

Table 6.21 Season I meteorological data

Temperature (°C)		Total Rainfall (mm)	$Humidity_{avg}$ (%)	Wind $speed_{avg}$ (m/s)	Predominant wind direction
Max_{avg}	Min_{avg}				
26.1	16.8	169	98.9	0.6	SE

During the season I predominant wind direction was found towards South East (SE), the temperature ranged between 16.8°C to 26.1°C, with a total rainfall of 169 mm. The windrose plot for season I is given in Figure 6.7.

Figure 6.7 Windrose plot – Season I

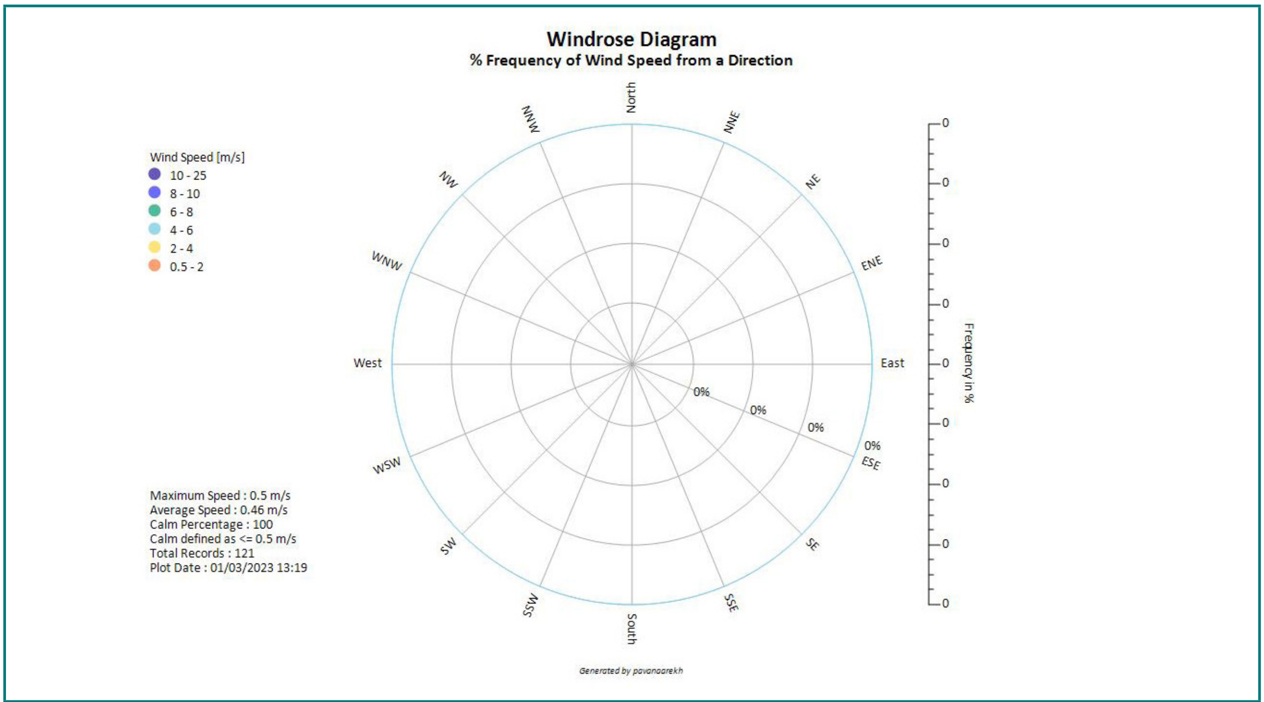
The wind rose plot and details of meterological condition for season II are given in Table 6.22.

Table 6.22 Season II meteorological data

Temperature (°C)		Total Rainfall (mm)	Humidity$_{avg}$ (%)	Wind speed$_{avg}$ (m/s)	Predominant wind direction
Max$_{avg}$	Min$_{avg}$				
23.6	16.3	17	96.7	0.4	--

During the season II there was no predominant wind direction, since the wind speed is <0.5 m/s and this is called calm period. The temperature ranged between 16.3°C to 23.6°C, with a total rainfall of 17 mm. The windrose plot for season I is given in Figure 6.8.

Figure 6.8 Windrose plot – Season II



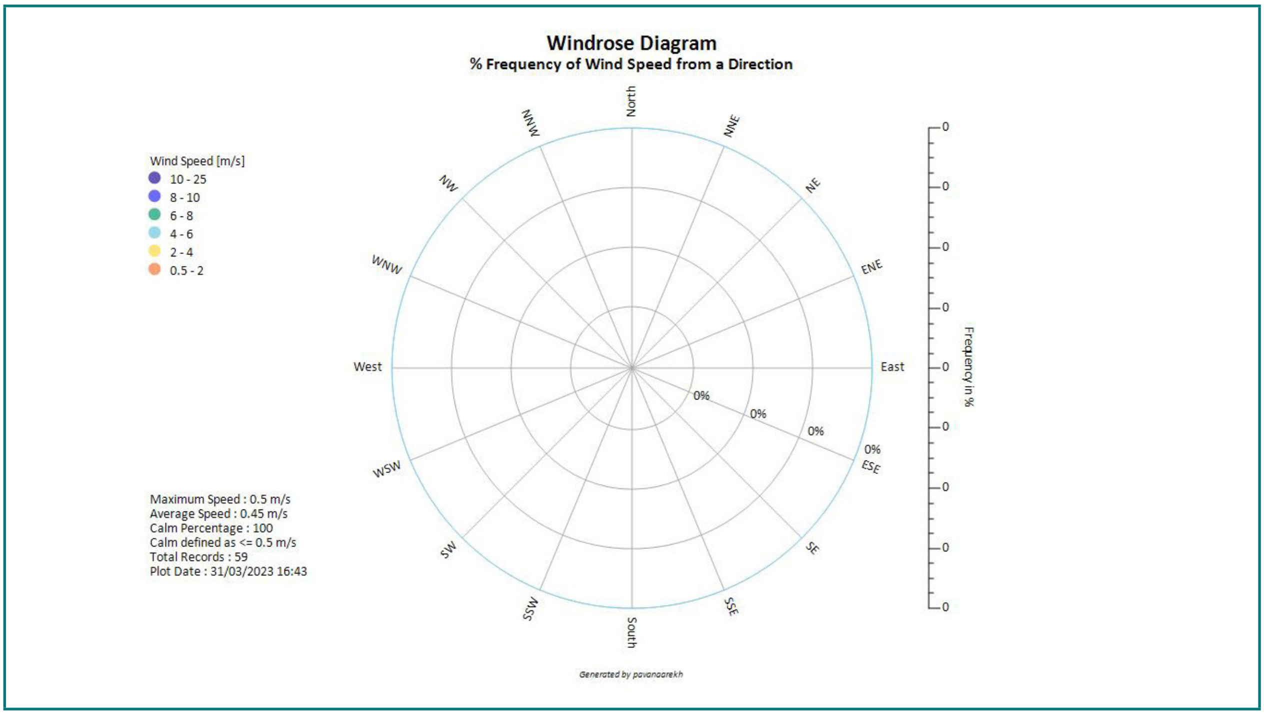
The wind rose plot and details of meterological condition for season III are given in Table 6.23.

Table 6.23 Season III meteorological data

Temperature (°C)		Total Rainfall (mm)	Humidity$_{avg}$ (%)	Wind speed$_{avg}$ (m/s)	Predominant wind direction
Max$_{avg}$	Min$_{avg}$				
26.2	16.2	0	74.5	0.4	--

During the season III there was no predominant wind direction, since the wind speed is <0.5 m/s and this is called calm period. The temperature ranged between 16.2°C to 26.2°C, with no rainfall. The windrose plot for season I is given in Figure 6.9.

Figure 6.9 Windrose plot – Season III



7 Socio-Economic Survey

In the first year annual report, socio-economic survey details of Devadari DHPC are given completely. The results obtained through a questionnaire survey in Tunga & Bhadra DHPC and Rama DHPC study area are presented as follows.

7.1 Tunga & Bhadra DHPC

A total of 1,619 households were surveyed in 14 villages of Tunga & Bhadra DHPC study area. The details of villages and households surveyed are given in Table 7.1.

Table 7.1 Villages surveyed in Tunga & Bhadra DHPC

	Village name	Households number (Census, 2011)	10% of Households	Number of households surveyed
1	Bannihatti	425	43	44
2	Kodalu	426	43	50
3	Kurekuppa	5306	531	537
4	Lingadahalli	270	27	29
5	Marutala	43	5	11
6	Muraripura	202	21	21
7	Nagalapura	372	38	39
8	S. Basapura	385	39	39
9	S. Gangalapura	161	17	17
10	Taluru	891	90	92
11	Taranagar	1343	135	141
12	Toranagallu	2407	241	242
13	Ubbalagundi	348	35	35
14	Vaddu	3215	322	322
	Total	**15,794**	**1,587**	**1,619**

7.1.1 General information

Results related to general information of Tunga & Bhadra DHPC are given in Table 7.2.

Table 7.2 Results of socio-economic survey

	Parameters		Respondents	
			Number	%
1	Religion	Hindu	1512	93.4
		Muslim	104	6.4
		Christian	3	0.2
		Others	-	-

	Parameters		Respondents	
			Number	%
2	Caste	GM	460	28.4
		OBC	485	30
		SC/ST	674	41.6
		Others	-	-
3	Mother tongue	Kannada	1512	93.4
		Telugu	9	0.6
		Hindi	13	0.8
		Others	85	5.3
4	Qualification of family head	Primary	258	15.9
		High school	524	32.4
		Graduation	305	18.8
		None	532	32.9
5	Occupation of family head	Farmer	306	18.9
		Govt employee	15	0.9
		Private	296	18.3
		Others	1002	61.9
Note: GM **-** General Merit; OBC **-** Other Backward Class; SC/ST **-**Scheduled Caste/Scheduled Tribes.				

Results of various parameters revealed that:

- **Religion:** The majority community present is Hindu (93.4%) followed by Muslims (6.4%) and Christians (0.2%).
- **Caste:** About 41.6% of surveyed families belong to Scheduled Caste/Scheduled Tribes while rest belongs to Other Backward Classes (OBC) (30%) and General Merit (GM) (28.4%) respectively.
- **Mother tongue:** The majority of surveyed families speak Kannada (93.4%) while rest speak other languages (Urdu, Marathi, etc) (5.3%), Hindi (0.8%), and Telugu (0.6%).
- **Education level:** About 32.9% are illiterates while 32.4% and 18.8% had high school education and graduation respectively.
- **Occupation:** About 61.9% of surveyed families work in the unorganised sector followed by farming (18.9%), private (18.3%), and Government sector (0.9%) respectively.

Graphical representation of caste, education, and occupation information is given in Figure 7.1, 7.2, and 7.3 respectively.

Figure 7.1 Caste information of Tunga & Bhadra DHPC

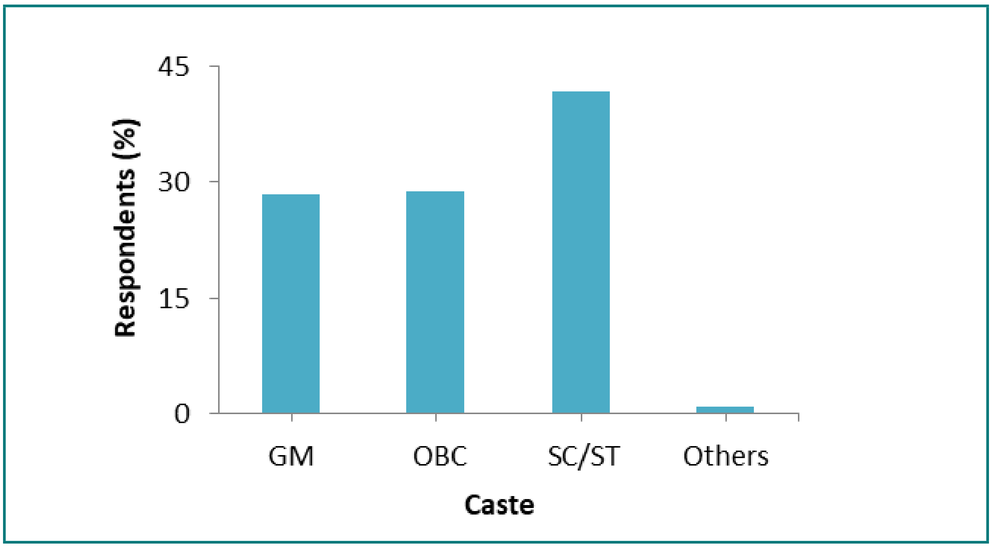


Figure 7.2 Education information – Tunga & Bhadra DHPC

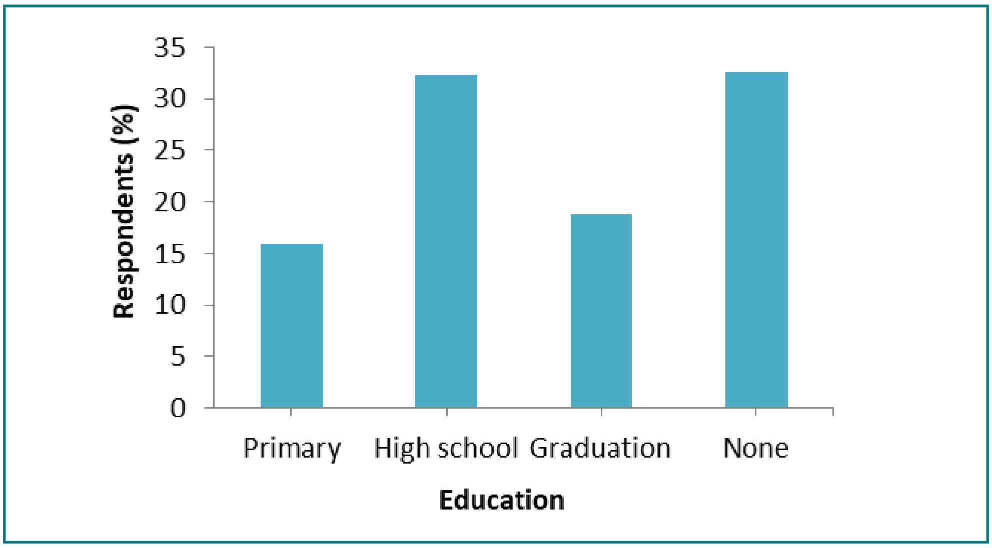
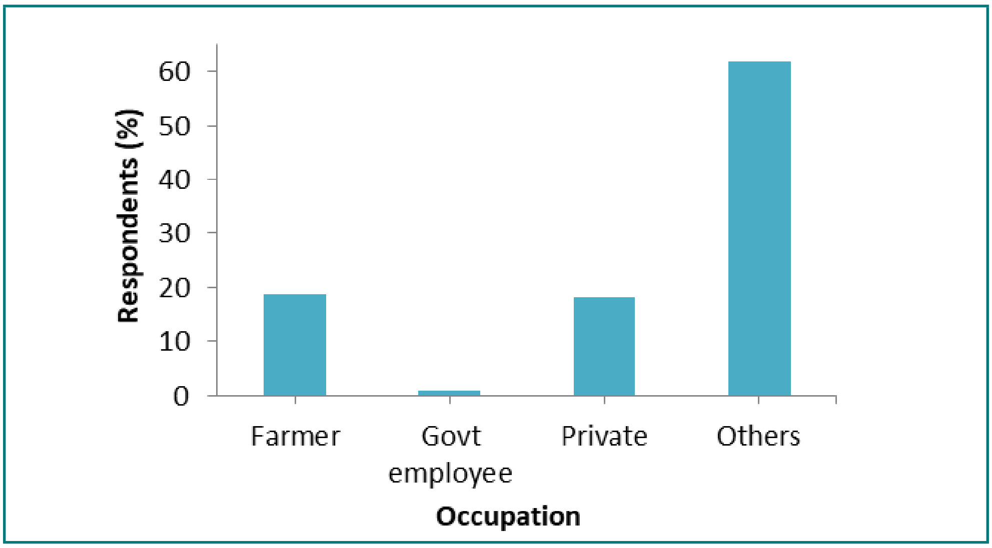


Figure 7.3 Occupation information – Tunga & Bhadra DHPC



7.1.2 Economic status

Results related to economic status of Tunga & Bhadra DHPC are given in Table 7.3.

Table 7.3 Results of economic status

	Parameters		Respondents	
			Number	%
1	Annual income of family head	<100000	255	15.8
		>100000	1001	61.8
		>200000	356	22
		>400000	7	0.4
2	Type of property	Land	306	18.9
		Building	1215	75
		Vehicle	95	5.9
		Others	3	0.2
3	Ownership of property	Own	1327	82
		Joint	26	1.6
		Rent	23	1.4
		Lease	230	14.2
4	Type of house	Concrete house	956	59
		Tiles house	10	0.6
		Sheet house	622	38.4
		Others	31	1.9
5	Electricity connection	Yes	1617	99.9
		No	2	0.1
6	Drinking water source	Borewell	142	8.8
		Surface water	-	-
		Open well	5	0.3
		Others	1472	90.9
7	Source of water for agriculture	Rain water	215	70.3
		Ground water	91	29.7
		Surface water	-	-
		Others	-	-
8	Livestock information	Cattles	43	2.7
		Sheep	14	0.9
		Chicks	5	0.3
		Others	-	-
		None	1557	96.2
9	Own vehicle	Two wheeler	1419	87.6
		Four wheeler	26	1.6
		Others	18	1.1
		None	156	9.6

	Parameters		Respondents	
			Number	%
10	Fuel used for cooking	LPG	1606	99.2
		Firewood	13	0.8
		Biogas	-	-
		Others	2	0.1
11	Agriculture machinery	Tractor/Tiller	23	1.4
		Bullock cart	19	1.2
		Others	1	0.1
		None	1576	97.3

Results of various parameters revealed that:

- **Annual income:** The majority of surveyed families are having an annual income of more than one lakh (61.8%) whereas 22%, 15.8%, and 0.4% of surveyed families annual income is found to be more than two lakhs, less than one lakh, and more than four lakhs.
- **Property type:** Building (75%) is the major property owned followed by land (18.9%).
- **Property ownership:** The majority of property ownership is solo (82%) type followed by leased (14.2%).
- **Type of house:** Around 59% of surveyed families live in concrete houses while 38.4% own sheet houses.
- **Electricity connection:** About 99.9% of surveyed households have electricity connections.
- **Drinking water source:** About 90.9% of surveyed families drink RO filter water followed by borewell (8.8%) and open well (0.3%) water.
- **Agriculture water source:** About 70.3% and 29.7% of surveyed families depend on rainwater and groundwater sources for irrigation.
- **Livestock information:** The majority of surveyed families (96.2%) didn't own livestock whereas 2.7% of cattle, 0.9% of sheep, and 0.3% of chick's population are recorded.
- **Vehicle ownership:** The majority of households own two-wheelers (87.6%) whereas 9.5% didn't own any vehicle followed by 1.6% of four-wheeler ownership.
- **Cooking fuel:** The majority of households use LPG (99.2%) as fuel for cooking followed by firewood (0.8%).
- **Agriculture machinery:** About 97.3% of surveyed families didn't own agriculture machinery whereas 1.4% of tractors/tillers and 1.2% of bullock carts are owned.

Graphical representation of the annual income, property type, and ownership is given in Figure 7.4, 7.5, and 7.6 respectively.

Figure 7.4 Graphical representation of annual income

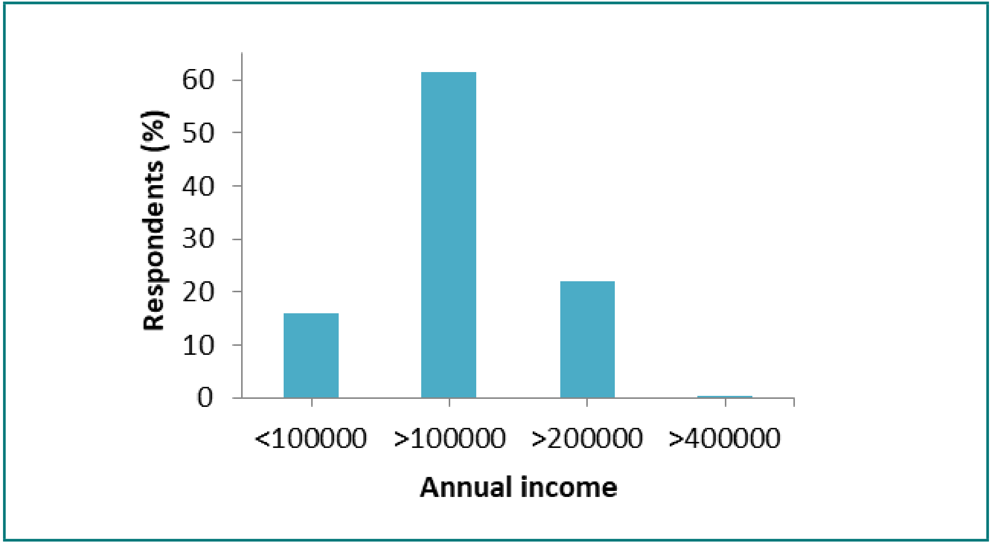


Figure 7.5 Graphical representation of property type

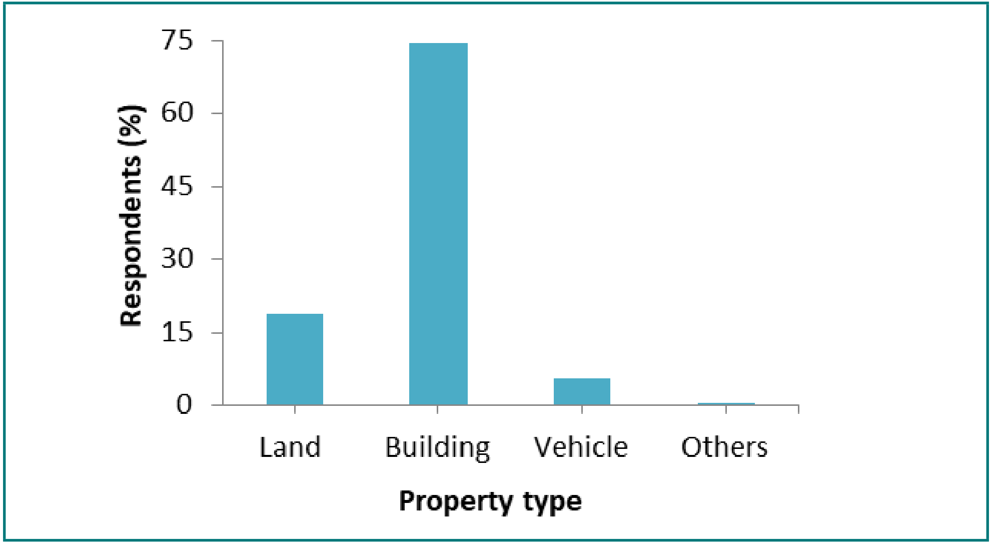
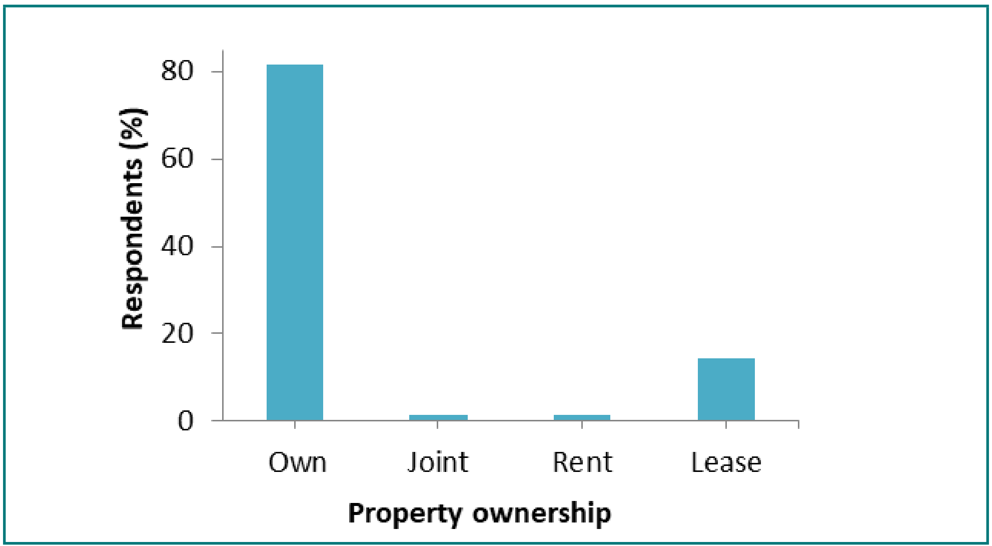


Figure 7.6 Graphical representation of property ownership



7.1.3 Dependency on mineral transportation for livelihood

Results related to dependency on mineral transportation are given in Table 7.4.

Table 7.4 Results of dependency on mineral transportation

	Parameters		Respondents	
			Number	%
1	Family dependent on mineral transportation for livelihood.	Directly dependent	72	4.4
		Indirectly dependent	63	3.9
		Not dependent	1484	91.7
2	Type of dependency on livelihood	Transport vehicle owner	23	1.4
		Vehicle driver/cleaner	52	3.2
		Shops on route	30	1.9
		Others	5	0.3
		None	1509	93.2
3	Financial impact of DHPC operation on family	Yes	115	7.1
		No	1504	92.9
4	Extent of effect on livelihood due to DHPC	≤ 25%	249	15.4
		≤ 50%	79	4.9
		≤ 75%	31	1.9
		≤ 100%	1	0.1
		None	1259	77.8

Results of various parameters revealed that:

- **Family dependency on livelihood:** About 4.4% and 3.9% of surveyed families are directly and indirectly dependent on mineral transportation for livelihood.
- **Type of dependency on livelihood:** The vehicle drivers/cleaners and vehicle owners dependency on transport vehicles for livelihood is found to be 3.2% and 1.4% respectively.
- **Financial impact:** About 7.1% of surveyed families have a financial impact whereas 92.9% of surveyed families are not impacted financially.
- **Effect on livelihood:** About ≤25%, ≤50%, ≤75%, and ≤100% effect on livelihood is recorded in 15.4%, 4.9%, 1.9%, and 0.1% of surveyed families respectively.

Graphical representation of financial dependency and impact is given in Figure 7.7 and 7.8.

Figure 7.7 Dependency of mineral transportation for livelihood

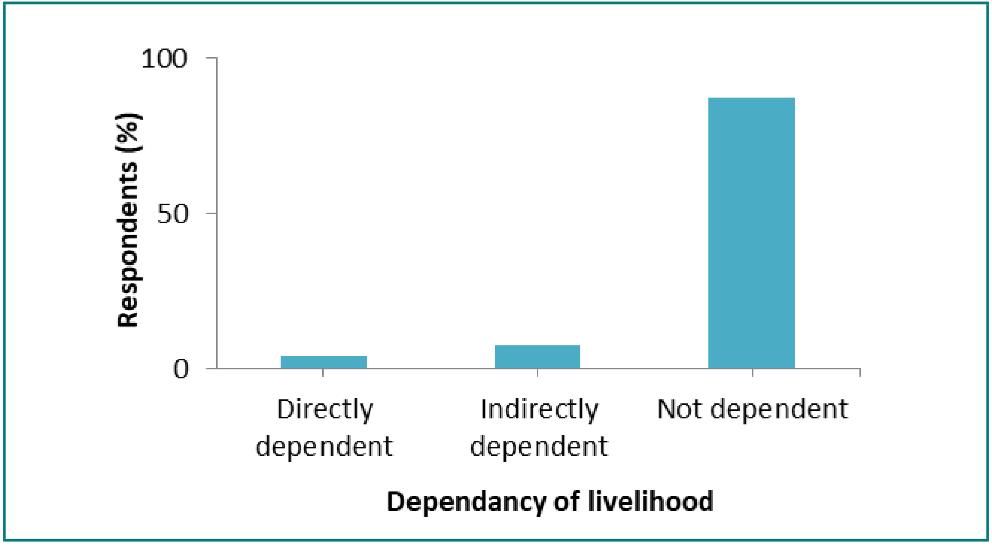
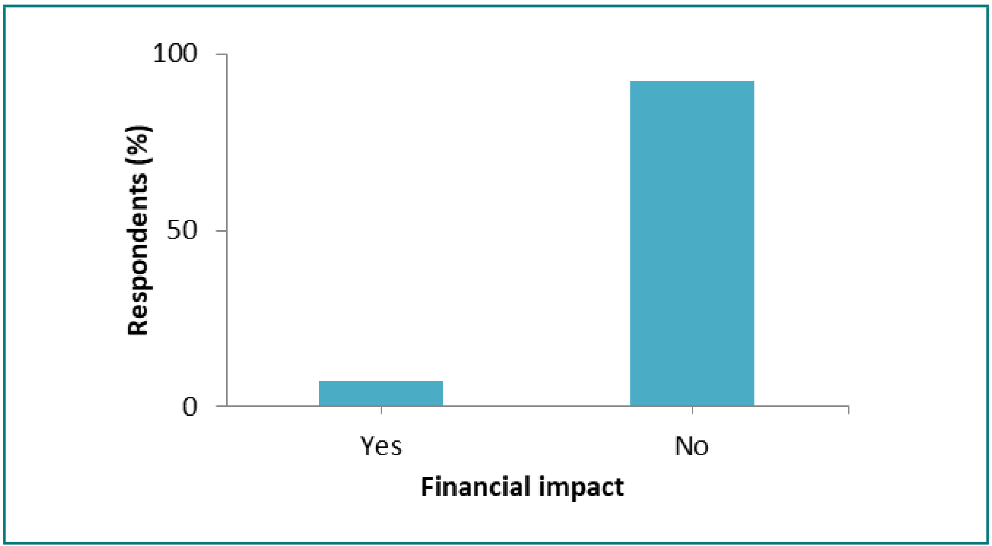


Figure 7.8 Financial impact due to operation



7.1.4 Local health information

Results related to local health information of Tunga & Bhadra DHPC are given in Table 7.5.

Table 7.5 Results of health information

	Parameters		Respondents	
			Number	%
1	Status of the surrounding environment	Highly polluted	133	8.2
		Moderately polluted	1376	85
		Less polluted	81	5
		Clean	29	1.8
2	Health facilities	Govt hospital	428	26.4
		Private hospital	7	0.4
		Private clinic	1005	62.1
		None	179	11.1

	Parameters		Respondents	
			Number	%
3	Family members suffering from illness	Bronchial disease	6	0.4
		Skin allergy	17	1.1
		Others	4	0.2
		None	1592	98.3
4	Type of health impacts	Headache	16	1
		Sleep disorder	6	0.4
		Hearing loss	-	-
		None	1597	98.6

Results of various parameters revealed that:

- **Surrounding environment:** The majority of surveyed families opinioned that the environment is moderately polluted (85%) followed by highly polluted (8.2%), least polluted (5%), and clean environment (1.8%).
- **Health facilities:** About 62.1% of health facility present is in the form of private clinic followed by Government hospital (26.4%) whereas 11.1% of surveyed families have an opinion that no health facility is available in the area/region.
- **Family member's illness:** Bronchial disease and skin allergy recorded is found to be 0.4% and 1.1% respectively whereas 98.3% of surveyed families didn't have any apparent illness.
- **Type of health impacts:** Headache and sleep disorder recorded is found to be 1% and 0.4% respectively whereas 98.6% of surveyed families didn't have any apparent health impacts.

Graphical representation of opinion on the surrounding environment and health facilities is given in Figure 7.9 and 7.10.

Figure 7.9 Opinion on the status of surrounding environment

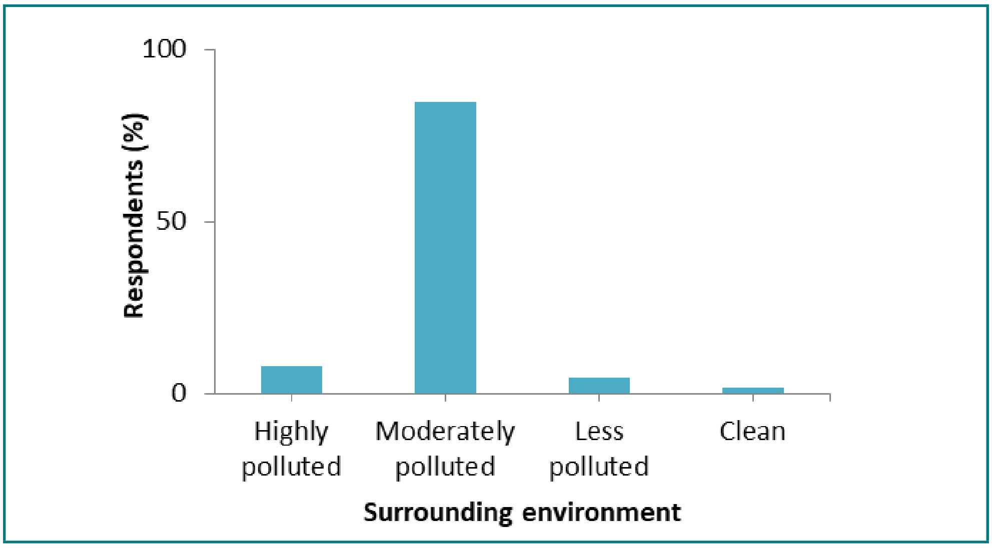
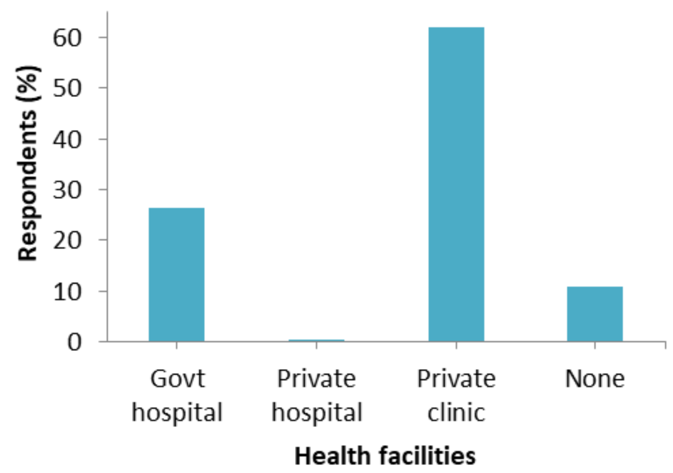


Figure 7.10 Health facilities in the study area



7.2 Rama DHPC

A total of 1,322 households were surveyed in 12 villages of Rama DHPC study area. The details of villages and households surveyed are given in Table 7.6.

Table 7.6 Details of villages surveyed in Rama DHPC

	Village name	Households number (Census, 2011)	10% Households	Number of households surveyed
1	Bandri	1313	132	139
2	Byalakundi	204	21	21
3	Danapura	42	5	10
4	Doulatpura	471	48	51
5	Garaga	397	40	40
6	Jaisingapura	539	54	54
7	Kakabalu	625	63	63
8	Nidugurthi	593	60	63
9	Ramgad	63	7	10
10	Sandur	7562	757	758
11	Siddapura	257	26	26
12	Sushilnagar	854	86	87
	Total	**12,920**	**1,299**	**1,322**

7.2.1 General information

Results related to general information of Rama DHPC are given in Table 7.7.

Table 7.7 Results of general information - Rama DHPC

	Parameters		Respondents	
			Number	%
1	Religion	Hindu	1120	84.7
		Muslim	182	13.8
		Christian	16	1.2
		Others	4	0.3
2	Caste	GM	37	2.8
		OBC	774	58.5
		SC/ST	509	38.5
		Others	2	0.2
3	Mother tongue	Kannada	1069	80.9
		Telugu	20	1.5
		Hindi	1	0.1
		Others	232	17.5
4	Qualification of family head	Primary	427	32.3
		High school	382	28.9
		Graduation	227	17.2
		None	286	21.6
5	Occupation of family head	Farmer	311	23.5
		Govt employee	51	3.9
		Private	18	1.3
		Others	942	71.3
Note: GM - General Merit; OBC - Other Backward Class; SC/ST -Scheduled Caste/Scheduled Tribes.				

In the Rama DHPC study area, a total of twelve villages comprising 1,322 households were surveyed. Results of various parameters revealed that:

- **Religion:** Hindu community (84.7%) is present in the majority followed by Muslims (13.8%) and Christians (1.2%).
- **Caste:** Other Backward Classes (OBC) (58.5%) are predominant followed by Scheduled Caste/Scheduled Tribes (38.5%) and General Merit (GM) (2.8%).
- **Mother tongue:** About 80.9% speak Kannada whereas 17.5% speak other languages (Urdu, Marathi, etc).
- **Education level:** About 32.3% and 28.9% had primary and high school education whereas 21.6% are illiterates and 17.2% are graduates respectively.
- **Occupation:** The majority of surveyed families work in the unorganised sector (71.3%) while 23.5%, 3.9%, and 1.4% occupation is in the farming, private, and Government sector respectively.

Graphical representation of caste, education, and occupation information is given in Figure 7.11, 7.12 and 7.13 respectively.

Figure 7.11 Caste information of Rama DHPC

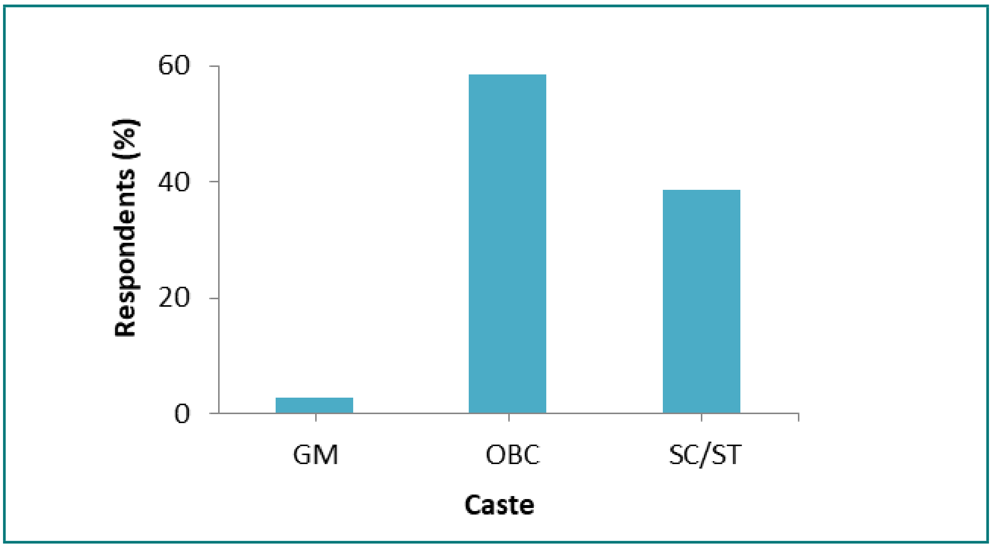


Figure 7.12 Education information – Rama DHPC

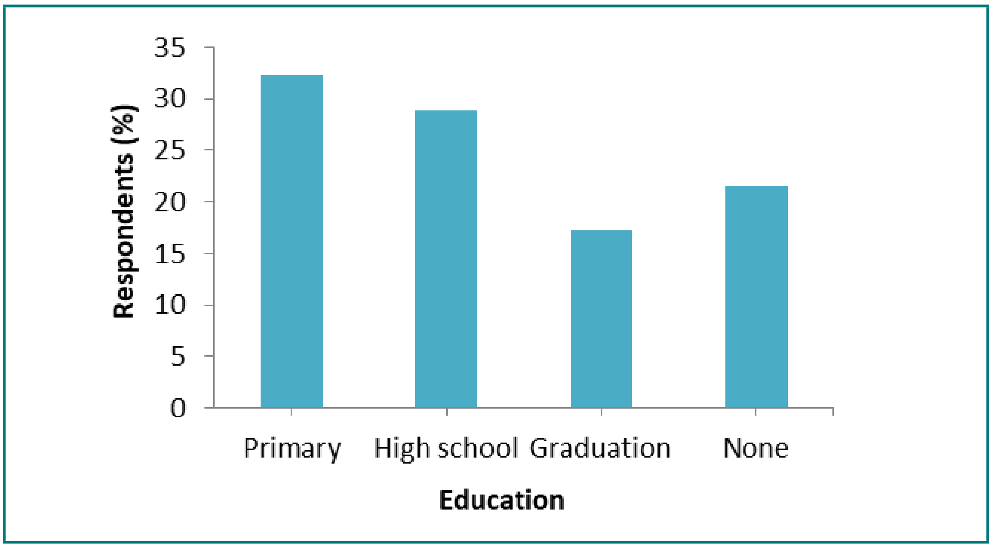
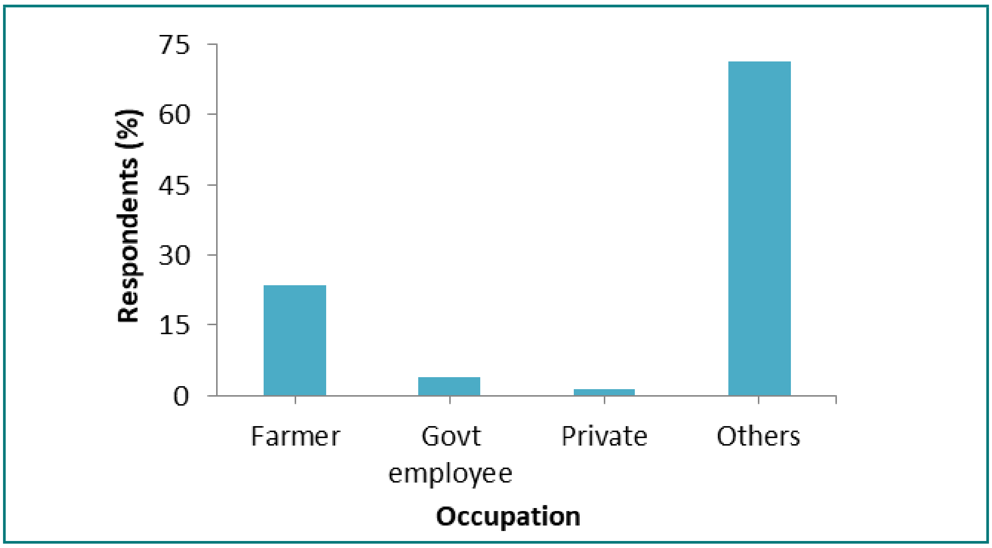


Figure 7.13 Occupation information – Rama DHPC



7.2.2 Economic status

Results related to economic status of Rama DHPC are given in Table 7.8.

Table 7.8 Results of economic status- Rama DHPC

	Parameters		Respondents	
			Number	%
1	Annual income of family head	<100000	636	48.1
		>100000	495	37.5
		>200000	113	8.5
		>400000	78	5.9
2	Type of property	Land	444	33.6
		Building	878	66.4
		Vehicle	-	-
		Others	-	-
3	Ownership of property	Own	1064	80.5
		Joint	-	-
		Rent	257	19.4
		Lease	1	0.1
4	Type of house	Concrete house	796	60.2
		Tiles house	74	5.6
		Sheet house	448	33.9
		Others	4	0.2
5	Electricity connection	Yes	1320	99.8
		No	2	0.2
6	Drinking water source	Borewell	425	32.1
		Surface water	1	0.1
		Open well	1	0.1
		Others	895	67.7
7	Source of water for agriculture	Rain water	349	78.6
		Ground water	90	20.3
		Surface water	-	-
		Others	5	1.1
8	Livestock information	Cattles	108	8.2
		Sheep	14	1
		Chicks	12	0.9
		Others	-	-
		None	1188	89.9
9	Own vehicle	Two wheeler	722	54.6
		Four wheeler	80	6.1
		Others	11	0.8
		None	509	38.5

	Parameters		Respondents	
			Number	%
10	Fuel used for cooking	LPG	1109	83.9
		Firewood	213	16.1
		Biogas	-	-
		Others	-	-
11	Agriculture machinery	Tractor/Tiller	23	1.7
		Bullock cart	1	0.1
		Others	2	0.2
		None	1296	98

Results of various parameters revealed that:

- **Annual income:** About 48.1% of the surveyed families are having an annual income of less than one lakh whereas 37.5%, 8.5%, and 5.9% of surveyed families annual income is found to be more than one lakh, more than two lakhs, and more than four lakhs.
- **Property type:** The major property owned is building (66.4%) followed by land (33.6%).
- **Property ownership:** The solo (80.5%) type of property ownership is major followed by rented (19.4%) and leased (0.1%).
- **Type of house:** Around 60.2% of surveyed families own concrete houses while 33.9% live in sheet houses followed by tiles houses (5.6%).
- **Electricity connection:** The majority (99.8%) of surveyed households have electricity connections.
- **Drinking water source:** The majority of surveyed families drink RO filter water (67.7%) followed by borewell water (32.1%).
- **Agriculture water source:** About 78.6% of surveyed families depend on rainwater while 20.3% rely on groundwater sources for irrigation.
- **Livestock information:** The majority of surveyed families (89.9%) didn't own livestock whereas 8.2% of cattle, 1% of sheep, and 0.9% of chick's population were recorded.
- **Vehicle ownership:** The majority of households own two-wheelers (54.6%) whereas 38.5% didn't own any vehicle followed by 6.1% of four-wheeler ownership.
- **Cooking fuel:** The majority of households use LPG (83.9%) as fuel for cooking followed by firewood (16.1%).
- **Agriculture machinery:** About 98% of surveyed families didn't own agriculture machinery whereas 1.7% owned Tractors/Tillers.

Graphical representation of the annual income, property type, and ownership is given in Figure 7.14, 7.15 and 7.16 respectively.

Figure 7.14 Graphical representation of annual income

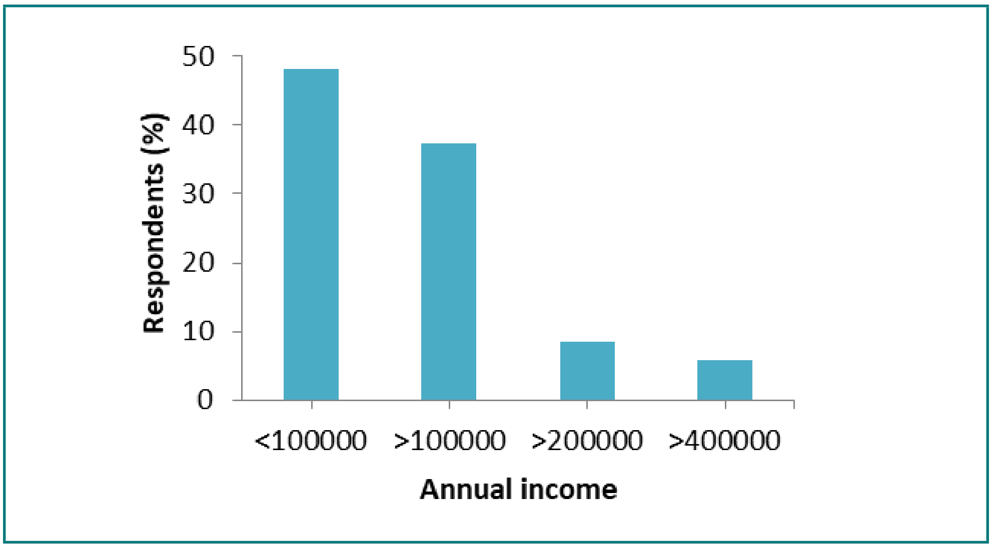


Figure 7.15 Graphical representation of property type

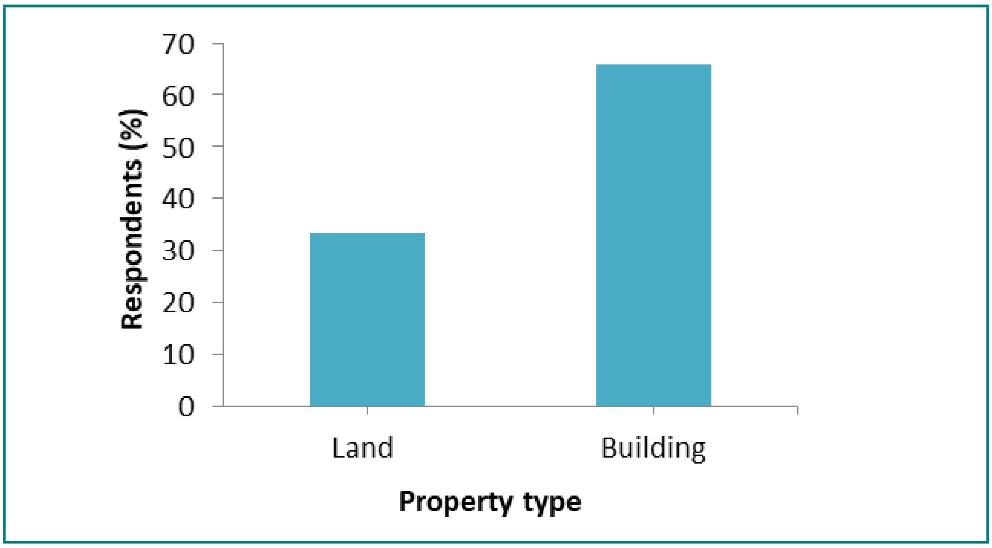
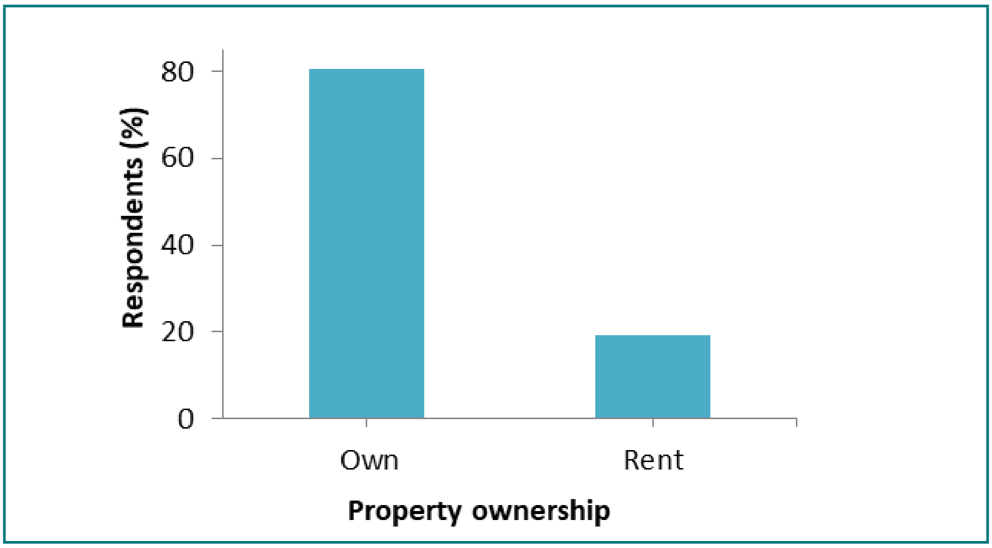


Figure 7.16 Graphical representation of property ownership



7.2.2 Dependency on mineral transportation for livelihood

Results related to dependency on mineral transportation are given in Table 7.9

Table 7.9 Results of dependency on mineral transportation- Rama DHPC

	Parameters		Respondents	
			Number	%
1	Family dependent on mineral transportation for livelihood	Directly dependent	250	18.9
		Indirectly dependent	5	0.4
		Not dependent	1067	80.7
2	Type of dependency on livelihood	Transport vehicle owner	20	1.5
		Vehicle driver/cleaner	216	16.3
		Shops on route	-	-
		Others	6	0.5
		None	1080	81.7
3	Financial impact of DHPC operation on family	Yes	269	20.3
		No	1053	79.7
4	Extent of effect on livelihood due to DHPC	≤ 25%	4	0.3
		≤ 50%	97	7.3
		≤ 75%	5	0.4
		≤ 100%	151	11.4
		None	1065	80.6

Results of various parameters revealed that:

- **Family dependency on livelihood:** A total of 80.7% of surveyed families are not dependent while the remaining 18.9% and 0.4% are directly and indirectly dependent on mineral transportation for livelihood.
- **Type of dependency on livelihood:** About 16.3% of vehicle drivers/cleaners and 1.5% of vehicle owners depend on transport vehicles for their livelihood.
- **Financial impact:** About 79.7% of surveyed families didn't have any financial impact whereas 20.3% of surveyed families are impacted financially.
- **Effect on livelihood:** About ≤100% and ≤50% effect on livelihood is recorded in 11.4% and 7.3% of surveyed families.

Graphical representation of financial dependency and impact is given in Figure 7.17 and 7.18.

Figure 7.17 Dependency on mineral transportation for livelihood

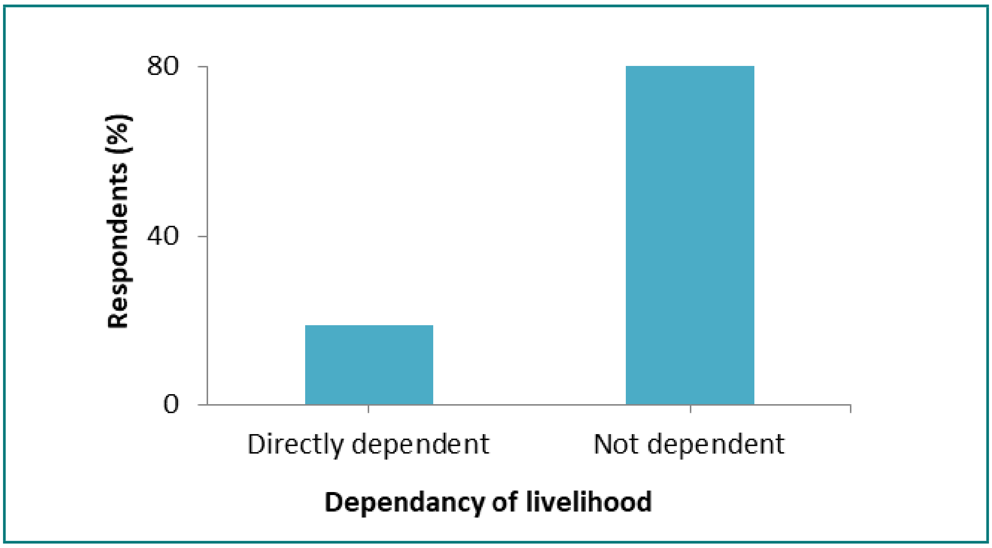
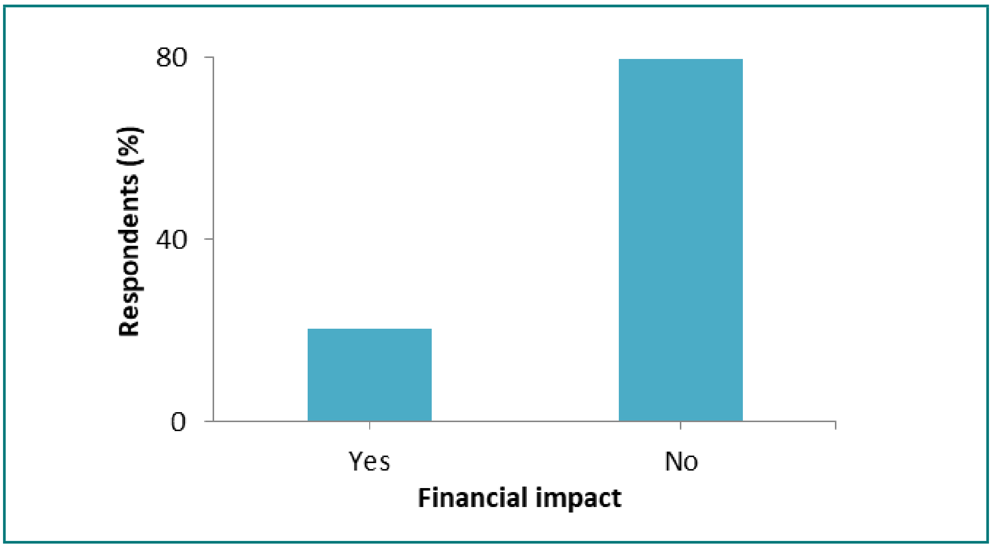


Figure 7.18 Financial impact due to operation of Rama DHPC



7.2.3 Local health information

Results related to local health information of Rama DHPC are given in Table 7.10.

Table 7.10 Results of health information- Rama DHPC

	Parameters		Respondents	
			Number	%
1	Status of the surrounding environment	Highly polluted	170	12.8
		Moderately polluted	634	48
		Less polluted	300	22.7
		Clean	218	16.5
2	Health facilities	Govt hospital	761	57.6
		Private hospital	-	-
		Private clinic	213	16.1
		None	348	26.3

	Parameters		Respondents	
			Number	%
3	Family members suffering from illness	Bronchial disease	77	5.8
		Skin allergy	112	8.5
		Others	-	-
		None	1133	85.7
4	Type of health impacts	Headache	132	9.9
		Sleep disorder	30	2.3
		Hearing loss	17	1.3
		None	1143	86.5

Results of various parameters revealed that:

- **Surrounding environment:** About 48% of surveyed families have an opinion that the environment is moderately polluted followed by 22.7% of least polluted, 16.5% of clean, and 12.8% of highly polluted environment.
- **Health facilities:** Government hospital (57.6%) is a major source of health facility present. About 26.3% of surveyed families opinioned that no health facility is available in the area/region.
- **Family member's illness:** About 85.7% of surveyed families didn't have any apparent illness whereas 8.5% of skin allergy and 5.8% of bronchial disease is recorded.
- **Type of health impacts:** About 86.5% of surveyed families didn't have any apparent health impacts whereas 9.9% of headache, 2.3% of sleep disorder, and 1.3% of hearing loss are recorded.

Graphical representation of opinion on the surrounding environment and health facilities is given in Figure 7.19 and 7.20.

Figure 7.19 Opinion on the status of surrounding environment

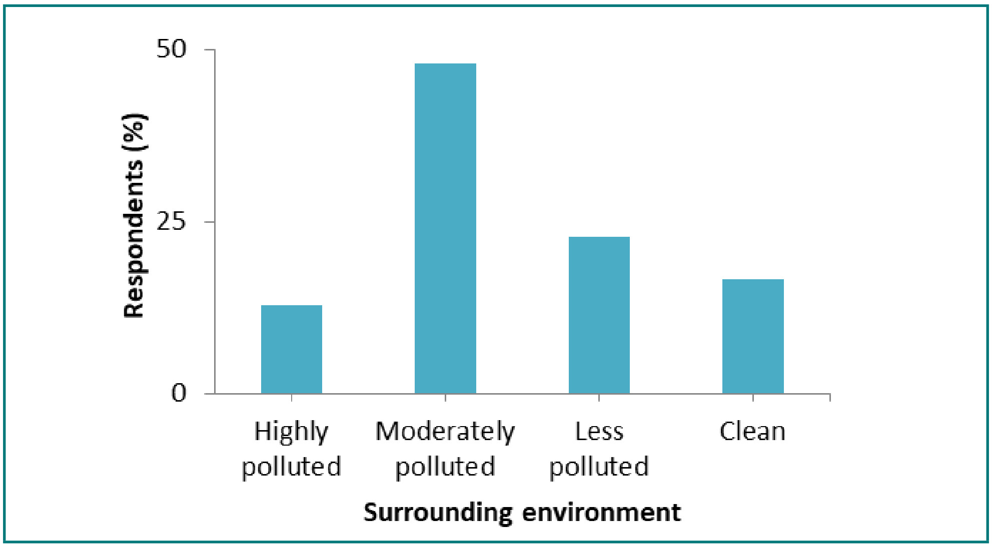
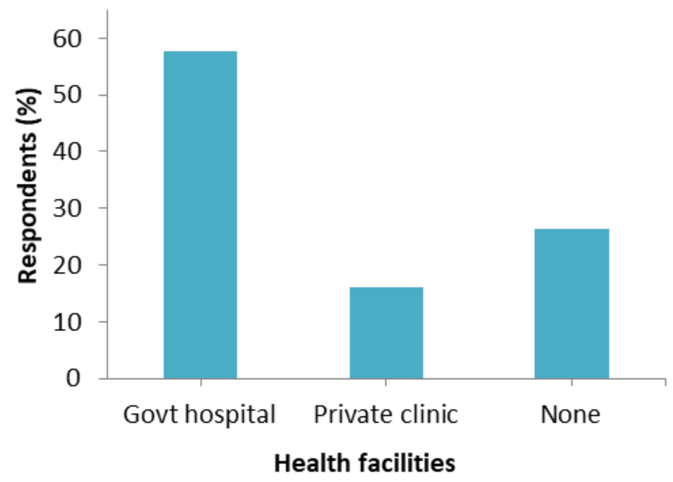


Figure 7.20 Health facilities in the study area



This chapter summarizes and presents socio-economic conditions of the study area, survey is conducted to assess the sociological and economic consequences of DHPC influenced areas. The survey mainly covers the construction stage of the project, the focus of the study is on the people living in the project area. The addressed components are the economic conditions of influenced villages and the basic facilities of the villages under the project area. Impacts will be assessed after the operation of the DHPCs. Decision on the influence of the project in a positive or negative way is made after assessing the operational phase of the DHPCs which provide comprehensive socio-economic impacts of the project.

8 Landuse and Landcover

The LU/LC classification is carried out for the year 2012 and 2022, 2018 and 2022, and 2021 and 2022 by visual interpretation technique. In first year annual report the LULC changes for the year 2012 and 2021, 2018 and 2021 was given. Accordingly, in this report the LULC classification for 2021 and 2022 is presented for each DHPC area.

8.1 Devadari DHPC

The statistics generated from GIS analysis for the year 2021 to 2022 in 10km buffer shows that Agricultural land is decreased by 4 Ha with the difference of 0.05%, whereas built up is increased by 72.98 Ha with the difference of 1.69%. Forest area is decreased by 72.14 Ha with a difference of 0.38%. Wasteland is decreased by 0.07% with 0.64 Ha. Water bodies are increased by 3.80 Ha with the difference of 0.58%. The detailed analysis LU/LC changes from 2021 to 2022 of level-I and level-III classifications is tabulated in the Table 8.1.

Table 8.1 LULC classification for Devadari DHPC

Level-I and III changes between 2021 and 2022						
Level	LULC Category	Area in Ha.				
		2021	2022	difference between 2021 and 2022	% difference	Remarks
Level-I	**Agricultural land**	**8131.01**	**8127.01**	**-4.00**	**-0.05**	**Decrease**
I	Agriculture plantation	184.49	189.17	4.68	2.47	Increase
II	Crop land	7946.52	7937.84	-8.68	-0.11	Decrease
Level-I	**Built up**	**4250.85**	**4323.83**	**72.98**	**1.69**	**Increase**
I	Built up (Rural)	173.28	177.37	4.09	2.31	Increase
II	Core urban	169.84	170.54	0.69	0.41	Increase
III	Hamlets and dispersed household	92.37	116.71	24.34	20.85	Increase
IV	Mining / industrial	3167.16	3209.53	42.37	1.32	Increase
V	Peri urban	56.87	57.02	0.15	0.27	Increase
VI	Transportation	316.29	316.29	0.00	0.00	No Change
VII	Village	275.04	276.37	1.33	0.48	Increase
Level-I	**Forest**	**19235.35**	**19163.21**	**-72.14**	**-0.38**	**Decrease**
I	Forest	19223.15	19151.01	-72.14	-0.38	Decrease
II	Forest plantation	12.20	12.20	0.00	0.00	No Change
Level-I	**Wastelands**	**955.64**	**955.00**	**-0.64**	**-0.07**	**Decrease**
I	Barren rocky	127.32	126.47	-0.85	-0.67	Decrease
II	Scrub land Dense	27.06	24.08	-2.98	-12.37	Decrease

Level-I and III changes between 2021 and 2022						
Level	LULC Category	Area in Ha.				
		2021	2022	difference between 2021 and 2022	% difference	Remarks
III	Scrub land Open	796.33	785.50	-10.83	-1.38	Decrease
IV	Waterlogged	4.93	18.96	14.03	73.99	Increase
Level-I	**Water bodies**	**646.05**	**649.84**	**3.80**	**0.58**	**Increase**
I	Canal	6.31	6.31	0.00	0.00	No Change
II	Lakes / Ponds	4.67	5.29	0.63	11.81	Increase
III	Reservoir / Tanks	328.47	331.64	3.17	0.96	Increase
IV	River / Stream / Drain	306.60	306.60	0.00	0.00	No Change
Grand Total		**33218.89**	**33218.89**			

An exclusive map showing the LU/LC level-III classifications for 2021 and 2022 are shown in the Figure 8.1 and 8.2 respectively.

8.2 Tunga & Bhadra DHPC

The statistics generated from GIS analysis for the year 2021 to 2022 in 10km buffer shows that Agricultural land is increased by 72.18 Ha with the difference of 0.58%, whereas built up is increased by 145.60 Ha with the difference of 2.43%. Forest area is decreased by 119.18 Ha with a difference of 0.72%. Wasteland is decreased by 3.04% with 103.86 Ha. Water bodies are increased by 5.26 Ha with the difference of 0.42%. The detailed analysis LU/LC changes from 2021 to 2022 of level-I and level-III classifications is tabulated in the Table 8.2.

Figure 8.1 Devadari LULC map for 2021 - 10km buffer

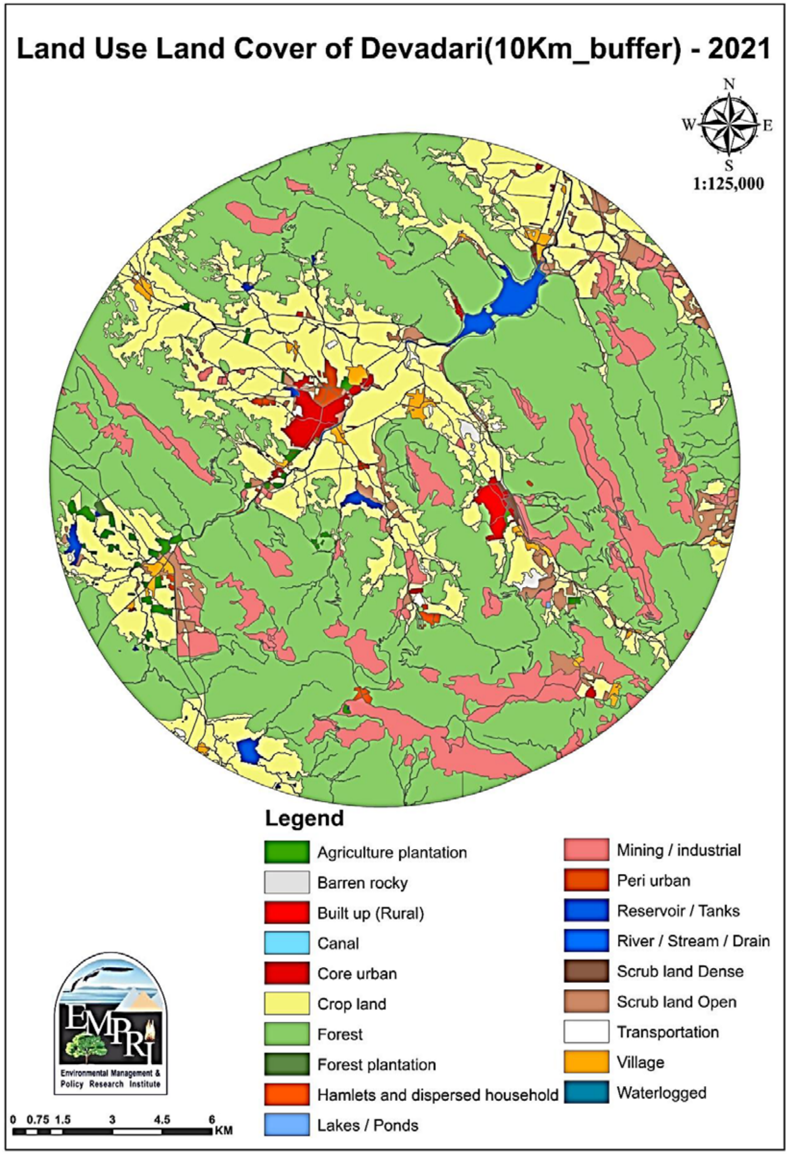


Figure 8.2 Devadari LULC map for 2022 - 10km buffer

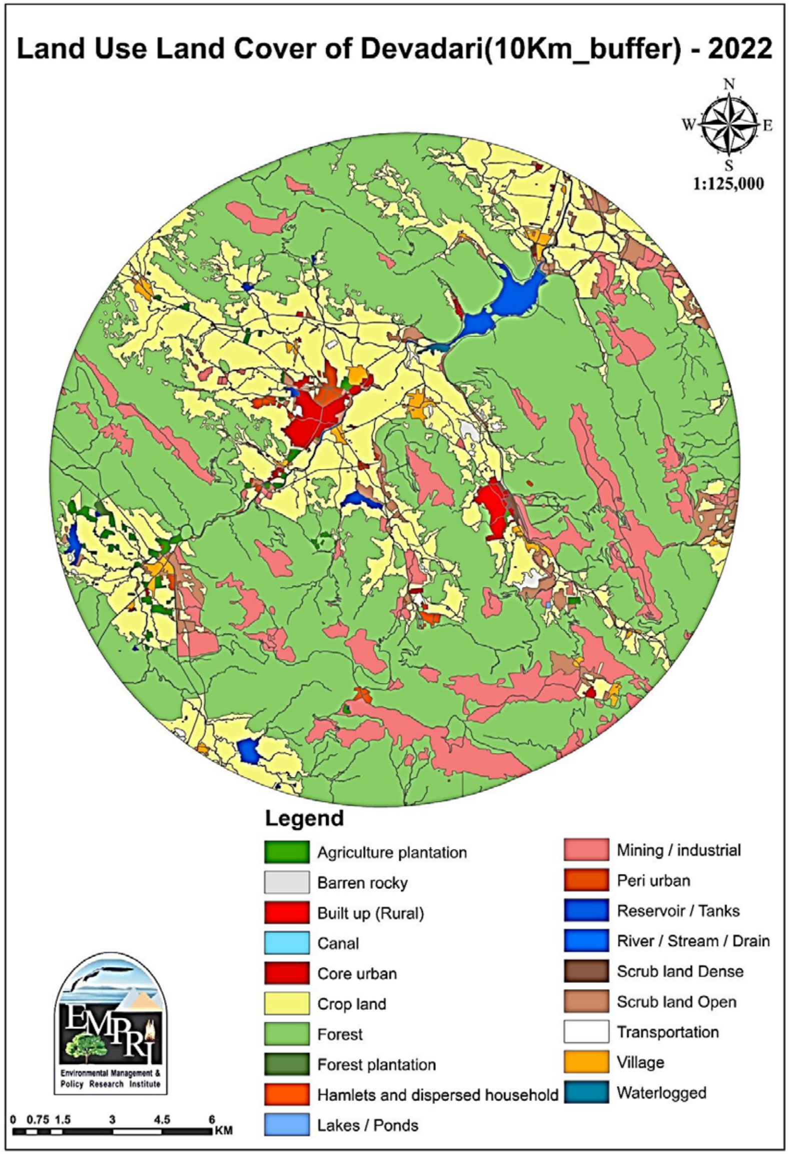


Table 8.2 LULC classification for Tunga & Bhadra DHPC

Level-I and III changes between 2021 and 2022						
Level	LULC Category	Area in Ha.				
		2021	2022	difference 2021 and 2022	% difference	Remarks
Level-I	**Agricultural land**	**12332.76**	**12404.94**	**72.18**	**0.58**	**Increase**
I	Agriculture plantation	40.14	43.18	3.05	7.06	Increase
II	Crop land	12292.62	12361.75	69.13	0.56	Increase
Level-I	**Built up**	**5840.77**	**5986.37**	**145.60**	**2.43**	**Increase**
I	Built up (Rural)	205.65	217.38	11.73	5.40	Increase
II	Built up (Urban)	66.94	67.58	0.64	0.95	Increase
III	Core urban	127.70	127.70	0.00	0.00	No Change
IV	Hamlets and dispersed household	113.81	136.50	22.69	16.62	Increase
V	Mining / industrial	4393.43	4496.88	103.45	2.30	Increase
VI	Peri urban	56.87	57.02	0.15	0.27	Increase
VII	Transportation	403.91	407.35	3.43	0.84	Increase
VIII	Village	472.47	475.97	3.50	0.74	Increase
Level-I	**Forest**	**16613.59**	**16494.42**	**-119.18**	**-0.72**	**Decrease**
I	Forest	16592.55	16473.37	-119.18	-0.72	Decrease
II	Forest plantation	21.05	21.05	0.00	0.00	No Change
Level-I	**Wastelands**	**3524.21**	**3420.35**	**-103.86**	**-3.04**	**Decrease**
I	Barren rocky	496.15	494.91	-1.24	-0.25	Decrease
II	Gullied / ravenous	6.42	6.42	0.00	0.00	No Change
III	Salt affected	59.49	57.03	-2.47	-4.33	Decrease
IV	Sandy areas	14.44	14.44	0.00	0.00	No Change
V	Scrub land Dense	30.01	27.04	-2.98	-11.02	Decrease
VI	Scrub land Open	2707.78	2596.68	-111.10	-4.28	**Decrease**
VII	Waterlogged	209.91	223.84	13.93	6.22	Increase
Level-I	**Water bodies**	**1240.94**	**1246.20**	**5.26**	**0.42**	**Increase**
I	Canal	25.73	25.73	0.00	0.00	No Change
II	Lakes / Ponds	38.35	40.86	2.51	6.13	Increase
III	Reservoir / Tanks	786.17	788.92	2.75	0.35	Increase
IV	River / Stream / Drain	390.69	390.69	0.00	0.00	No Change
Grand Total		**39552.27**	**39552.27**			

The LU/LC map of level-III classifications of 2021 and 2022 is shown in the Figure 8.3 and 8.4 respectively.

Figure 8.3 Tunga & Bhadra LULC map for 2021 - 10km buffer

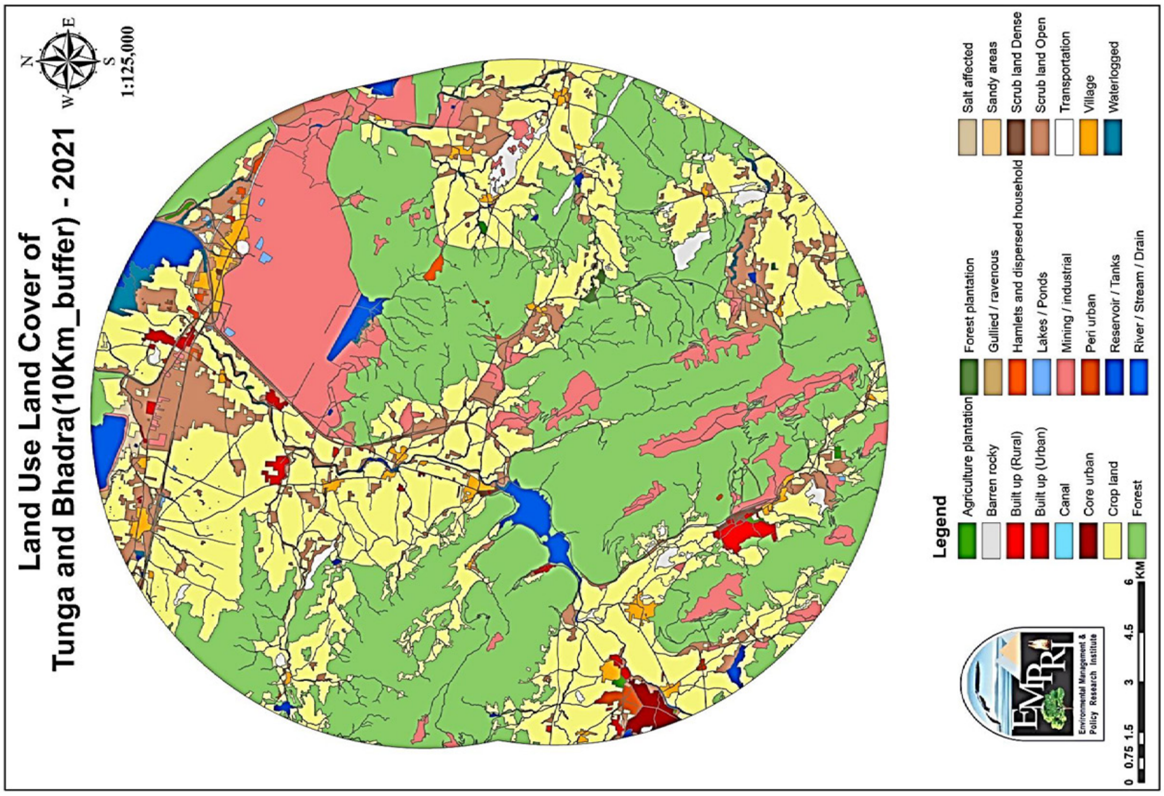
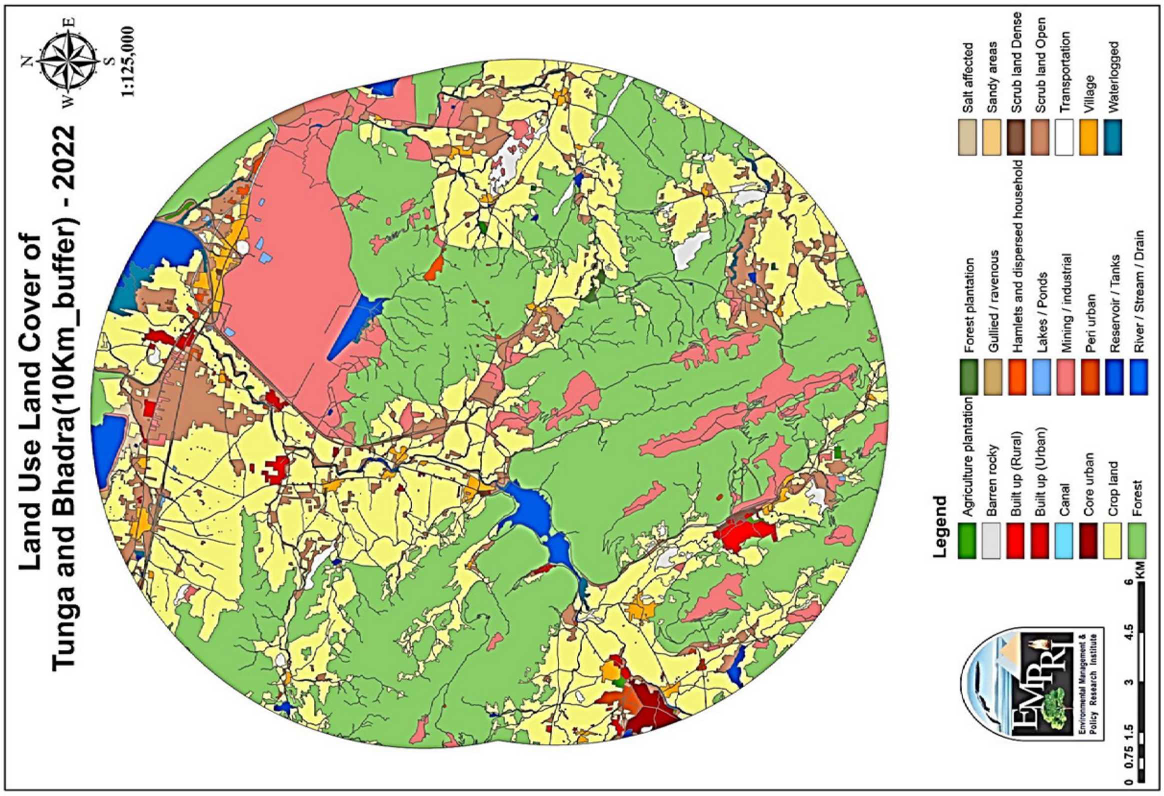


Figure 8.4 Tunga & Bhadra LULC map for 2022 - 10km buffer



8.2.1 Rama DHPC

The statistics generated from GIS analysis for the year 2021 to 2022 in 10km buffer shows that Agricultural land is increased by 50.33 Ha with the difference of 0.41%, whereas built up is increased by 54.55 Ha with the difference of 1.55%. Forest area is decreased by 81.02 Ha with a difference of 0.31%. Wasteland is decreased by 1.66% with 25.18 Ha. Water bodies are increased by 1.33 Ha with the difference of 0.12%. The detailed analysis LU/LC changes from 2021 to 2022 of level-I and level-III classifications is tabulated in the Table 8.3.

Table 8.3 LULC classification for Rama DHPC

Level-I and III changes between 2021 and 2022						
Level	LULC Category	Area in Ha.				
		2021	2022	difference 2021 and 2022	% difference	Remarks
Level-I	**Agricultural land**	**12203.30**	**12253.63**	**50.33**	**0.41**	**Increase**
I	Agriculture plantation	195.44	201.63	6.18	3.07	Increase
II	Crop land	12007.86	12052.00	44.14	0.37	Increase
Level-I	**Built up**	**3458.01**	**3512.56**	**54.55**	**1.55**	**Increase**
I	Built up (Rural)	170.34	173.70	3.36	1.94	Increase
II	Core urban	169.84	170.54	0.69	0.41	Increase
III	Hamlets and dispersed household	64.06	90.59	26.53	29.29	Increase
IV	Mining / industrial	2350.15	2372.57	22.42	0.95	Increase
V	Peri urban	56.87	57.02	0.15	0.27	Increase
VI	Transportation	323.12	323.13	0.01	0.00	No Change
VII	Village	323.63	325.01	1.37	0.42	Increase
Level-I	**Forest**	**26547.32**	**26466.30**	**-81.02**	**-0.31**	**Decrease**
I	Forest	26535.11	26454.10	-81.02	-0.31	Decrease
II	Forest plantation	12.20	12.20	0.00	0.00	No Change
Level-I	**Wastelands**	**1538.32**	**1513.14**	**-25.18**	**-1.66**	**Decrease**
I	Barren rocky	536.02	534.22	-1.80	-0.34	Decrease
II	Salt affected	31.76	30.93	-0.83	-2.69	Decrease
III	Sandy areas	0.88	0.88	0.00	0.00	No Change
IV	Scrub land Dense	22.30	19.45	-2.84	-14.62	Decrease
V	Scrub land Open	944.02	910.28	-33.74	-3.71	Decrease
VI	Waterlogged	3.34	17.37	14.03	80.77	Increase
Level-I	**Water bodies**	**1155.71**	**1157.04**	**1.33**	**0.12**	**Increase**
I	Canal	5.61	5.61	0.00	0.00	No Change
II	Lakes / Ponds	24.12	26.18	2.06	7.87	Increase
III	Reservoir / Tanks	761.21	760.48	-0.73	-0.10	Decrease
IV	River / Stream / Drain	364.78	364.78	0.00	0.00	No Change
Grand Total		**44902.66**	**44902.66**			

The LU/LC map of level-III classifications of 2021 and 2022 is shown in the Figure 8.5 and 8.6 respectively.

8.3 Accuracy assessment

One of the most important steps at classification process is accuracy assessment. The aim of accuracy assessment is to quantitatively assess how effectively the interpretation of the images is classified. To analyse the accuracy assessment 1km*1km grids are laid for entire study area. A total of 860 Points (locations) were created in the classified image of the study area by placing the point at each grid. The points are verified on the high resolution google earth images and the LISS-IV satellite imageries.

The overall accuracy percentage is calculated by the following formula

$$\therefore \text{Classification accuracy percentage} = \frac{\text{No. of correct sampled points}}{\text{total number of sample points}} * 100$$

$$\text{Classification accuracy percentage} = \frac{846}{860} * 100 = 98.37\%$$

The overall accuracy percentage obtained is 98.37%.

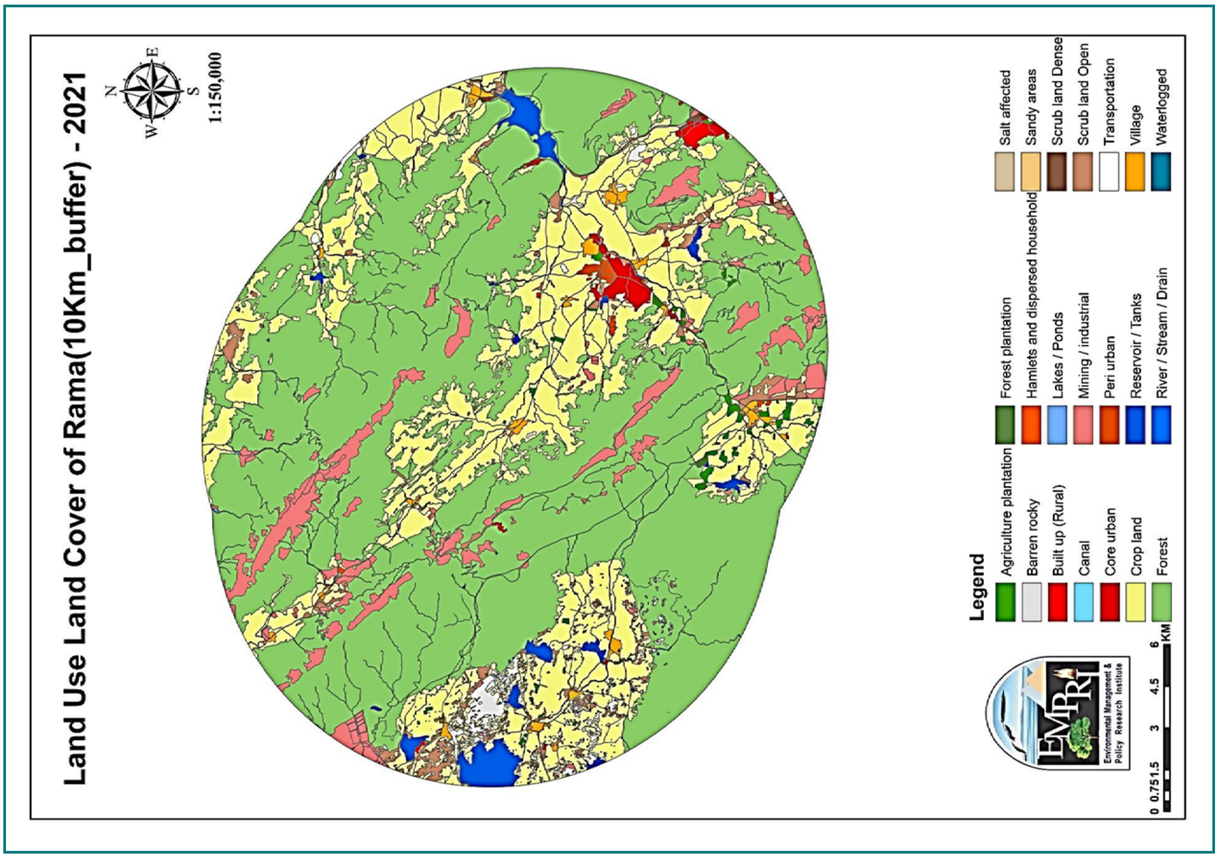


Figure 8.5 Rama LULC map for 2021 - 10km buffer

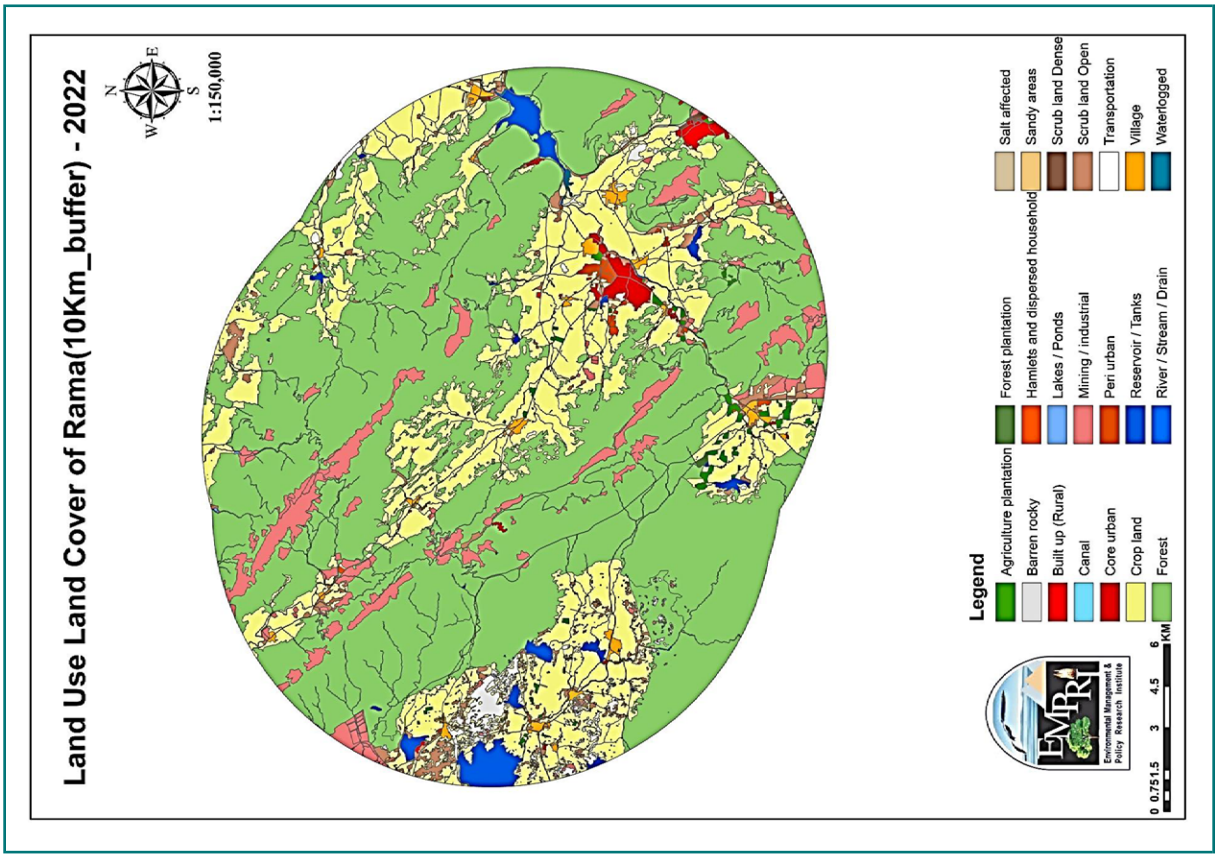


Figure 8.6 Rama LULC map for 2022 - 10km buffer

- The study area mainly consists of forest land, followed by agriculture, built up, wasteland and water bodies.
- Forest land is the mainly affected area under LU/LC in the study area between 2021 and 2022. An extent of 72.14 Ha, 119.18 Ha and 81.02 Ha of forest lands are decreased in 10km buffer of Devadari, Tunga & Bhadra and Rama DHPC respectively.
- An extent of 72.14 Ha, 119.18 Ha and 81.02 Ha of forest lands in 10km buffer of Devadari, Tunga & Bhadra and Rama DHPC respectively are converted to other LU/LC classes mainly to mining/ industrial area and built-up area. Due to these changes the natural resources and biodiversity in the ecosystem are lost.
- Apart from Forest land, the major land use change that has been observed in this study area is an increase in mining/industrial area to an extent of 42.37 Ha in Devadari, 103.45 Ha in Tunga & Bhadra and 22.42 Ha in Rama DHPC. This change in LU/LC includes major portion of forest land, getting converted into mining/industry.

9 Summary and conclusion

The following are the major conclusions of the study:

i. The construction of Devadari DHPC is complete and is expected to operate soon. However, construction of Tunga & Bhadra DHPC is underprogress and the construction of Rama DHPC is not yet started

ii. Four water bodies were inventoried in Rama DHPC area, one water body in Devadari DHPC. Whereas no active water bodies were found in Tunga and Bhadra DHPC study area.

iii. The surface water results of monitored water bodies were compared with designated water quality classification given by CPCB. The surface water results were found to be well within the standards for all the parameters except Dissolved Oxygen and Faecal coliform. This resulted in poor water quality category. However, the water quality of Chinnappanakola was found to be category A in the first season of monitoring.

iv. Twelve Groundwater samples were collected, analysed and compared with IS 10500: 2012 Drinking water standards. Results have revealed that Total Dissolved Solids, Total hardness, and Total alkalinity were beyond the acceptable limits whereas Iron, Aluminium, Manganese, Lead, Cadmium, Total Chromium, and Total Arsenic concentration exceeded the permissible limits in the study area.

v. In three DHPCs, 14 locations were identified for study of PM_{10}, $PM_{2.5}$, NO_2 and SO_2 concentration in season I, II and III. The observation is that the PM_{10} concentrations in all the 14 locations were beyond the National Ambient Air Quality Standards. Out of 14 locations $PM_{2.5}$ concentrations were higher than the National Ambient Air Quality Standards in 12 locations except Lakshmipura village (54.8µg/m^3 in season II) and Ramgad village (45.3µg/m^3 in season II and 51.1µg/m^3 in season III). Highest Particulate Matter concentration was recorded in Devadari transfer point (PM_{10} - 462.8µg/m^3 and $PM_{2.5}$ - 132.4µg/m^3) in season I. NO_2 and SO_2 concentration in all the locations and seasons were within the National Ambient Air Quality Standards.

vi. The noise levels observed in the study area were beyond the CPCB standards except in Bannihatti transfer point in season I, II and III both during day and night time.

vii. Soil results revealed that the soil is acidic to alkaline with higher Electrical Conductivity in all locations and seasons. Hydrological Soil Group classification revealed that major type of soil present in the study area was silt or loam.

viii. Meteorological data showed average minimum temperature of 10°C and average maximum temperature of 27.3°C as per recorded primary data in Devadari DHPC

(Season II) and Tunga & Bhadra DHPC (Season III). Maximum rainfall of 458 mm in Devadari DHPC (Season I) and average minimum humidity of 74.5% was observed in Rama DHPC (Season III). Predominant wind direction in the study area was found to be South-West in Devadari DHPC (Season II) and Tunga & Bhadra DHPC (Season I & II) whereas South-East in Rama DHPC (Season I).

ix. Socio-economic survey carried out in fourteen villages of Tunga & Bhadra DHPC and twelve villages of Rama DHPC revealed that the socio-economic conditions of surveyed families remained same in construction phase of the study.

x. Land use and Land cover study in 10 km buffer of Devadari, Tunga & Bhadra and Rama DHPCs showed a decrease in the area of forest land of 72.14 Ha, 119.18 Ha and 81.02 Ha respectively with major portion converted to mining/industrial area and built-up area, as a result the natural resources and biodiversity in the ecosystem is lost.

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Annexure I Letter from KFD

File No.KFD/HOFF/A5-1(MNG)/46/2018-FC-KARNATAKA FOREST DEPARTMENT 100

ಕರ್ನಾಟಕ ಸರ್ಕಾರ
GOVERNMENT OF KARNATAKA

ಪ್ರಧಾನ ಮುಖ್ಯ ಅರಣ್ಯ ಸಂರಕ್ಷಣಾಧಿಕಾರಿ
(ಅರಣ್ಯ ಪಡೆ ಮುಖ್ಯಸ್ಥರು) ರವರ ಕಚೇರಿ
Office of the
Principal Chief Conservator of Forests
(Head of Forest Force)

ಅರಣ್ಯ ಭವನ, 18 ನೇ ಅಡ್ಡರಸ್ತೆ,
ಮಲ್ಲೇಶ್ವರಂ, ಬೆಂಗಳೂರು-560 003
Aranya Bhavan, 18th Cross
Malleshwaram, Bengaluru-560 003
Telephone : 080 2334 6472
Email: apccffc@gmail.com

Old File No: A5(1).MNG.CR-9/2017-18 E-66522
E-office File No. KFD/HOFF/A5-1(MNG)/46/2018-FC Date 24-07-2020

To,

M/s JSW Steel Limited
U 6th Floor, East Wing, Raheja Towers
M.G. Road, Bengaluru - 560 001

M/s JSW Steel Limited
Vijayanagar Works
Post Office - Vidyanagar
Sandur Taluk, Ballari District – 583 275

Sir,

Sub: Terms of Reference (ToR) for (i) the Study on Impact of Downhill Pipe Conveyor on wildlife in the landscape and ambient environment proposed to be conducted by the Wildlife Institute of India (WII), Dehradun and by Environmental Management and Policy Research Institute (EMPRI), Bengaluru, And (ii) the Study on Impact of Downhill Pipe Conveyor on wildlife due to increase in operation timings of conveyor belt system during experimental phase of four months

FC Proposal No. FP/KA/Others/26566/2017 *[Stage-I approved]*
FC Proposal No. FP/KA/Others/27706/2017 *[Stage-I approved]*
FC Proposal No. FP/KA/Others/27780/2017 *[Stage-I approved]*

Ref:

1. Government of India, Ministry of Environment, Forests & Climate Change (FC Division), New Delhi letter F.No. 8-07/2018-FC (Vol.) dated 28-12-2018 *[Stage-I approval; 5.271 ha]*
2. Government of India, Ministry of Environment, Forests & Climate Change (FC Division), New Delhi letter F.No. 8-12/2018-FC (Vol.) dated 31-12-2018 *[Stage-I approval; 0.604 ha]*
3. Government of India, Ministry of Environment, Forests & Climate Change (FC Division), New Delhi letter F.No. 8-14/2018-FC (Vol.) dated 31-12-2018 *[Stage-I approval; 15.981 ha]*
4. Government of India, Ministry of Environment, Forests & Climate Change (FC Division), New Delhi letter F.No.FC-11/274/2019-FC dated 13-01-2020 *[permission to extend operation timings of conveyor belt system from morning 6 AM to night 2 AM (totally 20 hours) on experimental basis for four months]*
5. This office letter of even number dated 03-02-2020 *[addressed to Director General, EMPRI Bengaluru and Director, WII Dehradun seeking ToR for the proposed studies]*
6. Director General, Environmental Management and Policy Research institute (EMPRI), Bengaluru letter No. CLC/JSW-Project/CR-13/2019-20 dated 02-

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03-2020 *[preliminary ToR]* and 22-05-2020 *[revised ToR]*

7. Director, Wildlife Institute of India, Dehradun letter No. WII-EIA/2019-2020/ EIA_STUDIES_CONVEYOR PIPE(110)-MO dated 09-07-2020 *[submission of ToR]*

The Government of India while according Stage-I approvals vide Ref (1), (2) and (3) for abovementioned three proposals under Section 2 of Forest (Conservation) Act, 1980 has stipulated the following condition that needs to be complied with by the User Agency for seeking the final (Stage-II) approval.

> *"(x) The User Agency shall conduct a study, at its own cost, involving a Reputed Institute on impact of downhill pipe conveyor on wildlife in the landscape and ambient environment. The State Forest Department will decide the ToR for the study. The study may be conducted for a period of five years or as decided by the State Forest Department."*

Further, the Government of India vide Ref (4) has permitted to extend the operational times of conveyor belts system established by M/s JSW Steel Ltd on experimental basis subject to the following condition.

i. *The operation time of Conveyor* Belt established by M/s JSW Steel Ltd, Thorangal be extended from morning 6.00 AM to night 2.00 AM (totally 20.00 hours) on experimental basis for 04 months.

ii. *A study regarding impact on wildlife due to increase in operation timings of conveyor belt system during experimental phase shall be taken up. The study shall be conducted by an Institute of repute like Wildlife Institute of India and ToR of proposed study shall be finalized in consultation with the State Forest Department.*

iii. *The findings of the study will be shared with Forest Conservation Division of the Ministry whereas the cost of the study would be borne by the User Agency.*

Accordingly, this office vide Ref (4) letter has requested the Director General, Environmental Management and Policy Research Institute (EMPRI), Bengaluru and also the Director, Wildlife Institute of India (WII), Dehradun to prepare draft Terms of Reference (ToR) for the studies stipulated in the Stage-I approvals and that stipulated by Government of India vide Ref (4).

In response, the Director General, Environmental Management and Policy Research Institute (EMPRI), Bengaluru vide Ref (5) letter dated 02-03-2020 submitted the preliminary ToR for *ambient environment* component of the study. The same was discussed in the meeting held on 14-05-2020 under the chairmanship of Principal Chief Conservator of Forests (Head of Forest Force) at Aranya Bhavan, Bengaluru. Based on certain suggestions made during the meeting, the EMPRI vide Ref (5) letter dated 22-05-2020 has submitted the following revised Terms of Reference for the *ambient environment* component of the Long Term Study.

1. *Inventorization of water bodies within one kilometer radius in the corridor of DHPC line;*

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2. *Analysis of Surface Water and Groundwater Quality (Physico-chemical and Bacteriological analysis);*

3. *Monitoring Ambient Air Quality in the project area during construction and operation phases of DHPC (monitoring locations – within the corridor of the three Downhill Pipe Conveyors i.e. from individual mines to common Main/Trunk Pipe Conveyor, connecting to Vijayanagara Steel Plant, Forest Area, Agricultural land, settlements, industries/schools/colleges/hospitals (sensitive zones);*

4. *Monitoring Ambient Noise Levels at suitable intervals and locations in the project area (monitoring locations – within the corridor of the three Downhill Pipe Conveyors, i.e. from individual mines to common Main/Trunk Pipe Conveyor, connecting to Vijayanagara Steel Plant, Forest Area, Agricultural land, settlements, industries/schools/colleges/hospitals (sensitive zones);*

5. *Analysis of Soil quality in the project area at suitable locations (sampling locations – within the corridor of the three Downhill Pipe Conveyors i.e. from individual mines to common Main/Trunk Pipe Conveyor, connecting to Vijayanagara Steel Plant, Forest Area, Agricultural land, settlements, industries/schools/colleges/hospitals (sensitive zones);*

6. *Meteorological Monitoring in the project area (Temperature, Rainfall, Wind Direction, Relative Humidity and Wind Speed);*

7. *Socioeconomic survey (Assess the socio economic conditions of the people in the project influenced villages);*

8. *Land use/ land cover pattern analysis for the area will be done by using time series satellite imageries.*

Similarly, the Director, Wildlife Institute of India, Dehradun vide Ref (6) has submitted the following Terms of References (ToR) for study of the impacts of the existing /proposed Downhill Conveyer Belt and Increased Operation Time of the Main Conveyer Belt of JSW on wildlife in Sandur Taluk, Ballari District.

A. **Short Term Study: Evaluation of the Impacts of Increased Timings of the Operation of the Main Conveyer Belt from Nandihalli Railway Yard to JSW Plant on wildlife**

I. *Assessment of the present land use in the main conveyer belt corridor.*

II. *Identification of habitats of conservation significance within the area.*

III. *Assessment of the current baseline with respect to habitat status and use by wild animals within the belt conveyor corridor with the current operation of conveyor belt (for 12 hr duration).*

IV. *Study the effect of conveyer belt associated factors such as physical disturbance, noise and any other disturbance on wildlife and their habitat.*

V. *Assessment of animal use of the area during extended time of operation of the conveyor belt on an experimental basis.*

VI. *Comparison of impacts of increase in the period of conveyor belt operation on wildlife.*

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B. **Long Term Study: Evaluation of the Impacts of Existing / Proposed Downhill Pipe Conveyer Belts of JSW on the wildlife in the surrounding areas of Sandur Taluk**

I. *Assessment of the biodiversity value in the landscape of the proposed/existing Downhill Pipe Conveyer Belts.*

II. *Assessment of habitat use by wild animals in the landscape around existing and proposed Downhill Pipe Conveyer Belts.*

III. *Identify areas of conservation significance within the landscape influenced by the development of existing and proposed Downhill Pipe Conveyer Belts with respect to multiple taxa.*

IV. *Provide guidance for aligning conservation planning in the landscape that is ceased with challenges posed by working mines, ore transportation and ore processing units.*

The above Terms of References (ToR) submitted by the Director General, Environmental Management and Policy Research institute (EMPRI), Bengaluru vide Ref (5) letter dated 22-05-2020 and by the Director, Wildlife Institute of India, Dehradun vide Ref (6) letter dated 09-07-2020 have been examined and are hereby approved subject to following conditions.

i. **The date of commencement of the studies shall be communicated by the Study Proponents to the Deputy Conservator of Forests, Ballari Division marking a copy to the Chief Conservator of Forests, Ballari Circle and this office.**

ii. **The experimental phase of four months as stipulated by the Government of India shall commence from the date of start of the study by the Wildlife Institute of India. There is no scope for extension of this experimental phase without prior approval of Government of India.**

iii. **The cost of Study shall be completely borne by M/s JSW Steel Ltd (User Agency in the FC proposals) and paid directly to Study Proponent in accordance with their mutual agreement.**

iv. **The Study Proponent shall abide by the provisions of Karnataka Forest Act, 1963 and Rules 1969 and also the Wildlife (Protection) Act, 1972 and shall exercise due diligence while visiting the forest areas to undertake the study.**

v. **The Study Proponent shall submit Interim Reports periodically as well as the Final Report to the Deputy Conservator of Forests, Ballari Division, to Chief Conservator of Forests, Ballari Circle and to this office as per the schedule given in the Study Proposal.**

vi. **The Chief Conservator of Forests, Ballari Circle shall monitor the Study on quarterly basis and submit a report of the same to this office.**

vii. **The Study Proponent shall make a presentation of all Interim Reports periodically as well as the Final Report at the end of study period to the undersigned and shall make necessary modifications if directed by this office.**

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viii. **Any dispute between the two Parties (the Study Proponent and the Funding Agency) shall be internally resolved by the respective Parties amicably. The Government of India / Government of Karnataka / this office shall not be made a party to any financial or other dispute arising between the two Parties.**

ix. **Any other conditions that may be imposed by the Government of India / Government of Karnataka / this office in due course of time.**

Yours Faithfully

(Sanjai Mohan IFS)
Principal Chief Conservator of Forests
(Head of Forest Force)

Copy along with copy of the Study Proposals:

1. The Additional Chief Secretary to Government of Karnataka, Department of Forests, Ecology and Environment, M. S. Building, Bengaluru – 560 001 for kind information.
2. The Principal Chief Conservator of Forests (Wildlife) & Chief Wildlife Warden, Aranya Bhavan, Bengaluru for information.
3. The Additional Principal Chief Conservator of Forests (Forest Resource Management), Aranya Bhavan, Bengaluru for information.
4. The Chief Conservator of Forests, Ballari Circle, Ballari for information and further action as above.
5. The Deputy Conservator of Forests, Ballari Division, Ballari for information and further action as above. **You are directed to permit the extension of operational timings of conveyor belt(s) from the date of commencement of the study by the Wildlife Institute of India in accordance with the stipulation of Government of India.**
6. The Director General, Environmental Management and Policy Research institute (EMPRI), Hasiru Bhavana, J.P. Nagar, Vth Phase, Vinayaka Nagar Circle, Bengaluru – 560 078 for information and further action.
7. The Director, Wildlife Institute of India, Post Box No.18, Chandrabani, Dehradun, Uttarakhand– 248 001 for information and further action.

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Annexure II Air Quality Index calculator

Calculation of AQI

Date			Station City State
DD-MM-YYYY			

Pollutants		concentration in µg/m3 (except for CO)	Sub-Index	check
PM10	24-hr avg	345.50	296	1
PM2.5	24-hr avg	102.90	243	1
SO2	24-hr avg	0.00	0	0
NO2	24-hr avg	6.30	8	1
*CO (mg/m3)	max 8-hr	0.00	0	0
O3	max 8-hr	0.00	0	0
NH3	24-hr avg	0.00	0	0

Air Quality Index

AQI = 296

* Concentrations of minimum three pollutants are required; one of them should be PM10 or PM2.5

* The check displays "1" when a non-zero value is entered

Good (0–50)	Minimal Impact	Poor (201–300)	Breathing discomfort to people on prolonged exposure
Satisfactory (51–100)	Minor breathing discomfort to sensitive people	Very Poor (301–400)	Respiratory illness to the people on prolonged exposure
Moderate (101–200)	Breathing discomfort to the people with lung, heart disease, children and older adults	Severe (>401)	Respiratory effects even on healthy people

Annexure III Socio-economic survey questionnaire

Sl. No: _______

"Impact Assessment of Downhill Pipe Conveyor on Ambient Environment as stipulated by MoEF&CC"

Environmental Management and Policy Research Institute (EMPRI)

SOCIO-ECONOMIC SURVEY QUESTIONNAIRE

Study area: □ Devadari DHPC □ Tunga & Bhadra DHPC □ Rama DHPC

I. General information

Head of the family ____

Village Name ____

Hobli /Taluk ____

District ____

1. Gender: Male □ Female □ Others □
2. Age: __________
3. Religion:□ Hindu □ Muslim □ Christian □ Others
4. Caste:□ GM □ OBC □ SC/ST □ Others
5. Mother tongue: □ Kannada □Telugu □ Hindi□ Others
6. No of members in family ________________
7. Education level of the family head:□ Primary □ High school □ Degree □ None
8. Occupation of the family head: □ Farmer □Government employee □ Private □ Others

II. Economic status

9. Annual income of the family: < Rs 1,00,000 □ > Rs 1,00,000 □ > Rs 2,00,000 □ > Rs 4,00,000 □
10. Type of the property: □ Land in hectares_______ □ Building □ Vehicles □Others (__________________)
11. Ownership of the property: □ Own □ Joint □ Rent □ None

12. Type of house: Concrete house ☐ Tiles house ☐ Sheet house ☐Others

13. Electricity connection: Yes☐ No☐

14. Drinking water source: ☐ Borewell ☐ Surface water ☐ Open well ☐ Others

15. Source of water for agriculture: ☐ Rain water ☐ Groundwater☐ Surface water ☐ Others

16. Livestock information: ☐ Cattles ☐ Sheep ☐ Chicks ☐ Others

17. Own vehicle: ☐ Two wheeler ☐ Four wheeler ☐ Others ☐ None

18. Fuel used for the cooking: ☐ LPG ☐Firewood ☐ Biogas ☐ Others

19. Agricultural machinery: ☐ Tractor ☐ Bullock cart ☐ Others ☐ None

III. Dependency on mining transportation for livelihood

20. Does your family depend on mining transportation for livelihood?
☐Directly dependent ☐ Indirectly dependent ☐Not dependent ☐None

21. Type of dependency on livelihood
☐Transport vehicle owner ☐Vehicle cleaner/driver ☐Shops on route ☐Agriculture loss

22. Does operation of DHPC have any financial effect on your family?
☐Yes ☐No

23. Extent of effect on livelihood due to DHPC
☐ ≤ 25% ☐ ≤50% ☐ ≤75% ☐ ≤ 100%

IV. Local health information (If the DHPC is in ☐ construction or ☐operation phase)

24. Status of the surrounding environment
☐ Highly polluted ☐ Moderately polluted ☐ Less polluted ☐ Clean

25. Health facilities in your place
☐ Government hospital ☐ Private hospital ☐ Private clinics ☐ None

26. Any of your family members is suffering from any illness
☐ Bronchial disease ☐ Skin allergy ☐ Others (__________) ☐ None

27. Type of health impact observed in human beings
☐ Headache ☐ Sleep disorder ☐ Hearing loss ☐ None/Others (__________)

Name and age of the person surveyed Date:	Name and sign of the surveyor Date:

Annexure IV Field photographs

Surface water sampling

Groundwater sampling and preservation

Ambient Air Quality monitoring

Ambient Noise quality monitoring

Soil sampling

Visit to Meterological station

Discussion with professors at Agrometerological department, GKVK, Bengaluru

Discussion with Dr. D. Kalaivanan, IIHR, Bengaluru

Socio-economic survey

Laboratory analysis

Environmental Management & Policy Research Institute (EMPRI) is an autonomous institute established by Government of Karnataka under the Department of Forest, Ecology and Environment. It is registered as a society under the Karnataka Societies Registration Act, 1960. EMPRI undertakes applied and policy research and provides capacity building trainings on concurrent environmental issues relevant to the society. Research and assessments undertaken by the institute seek to encourage and enable decision making by government, institutions, industry, and civil society, to safeguard and manage the natural resources effectively. Fresh capabilities on impact and carrying capacity assessment for sustainable development, and baseline data and modelling for air pollution and climate change are being augmented.

Environmental Management & Policy Research Institute
Department of Forest, Ecology, and Environment, Government of Karnataka
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