ANNUAL REPORT

Impact Assessment of Downhill Pipe Conveyor on Ambient Environment

January 2021 to March 2022

Submitted to

Karnataka Forest Department
Government of Karnataka

Prepared by

Environmental Management & Policy Research Institute
Department of Forest, Ecology and Environment, Government of Karnataka
'Hasiru Bhavan', Doresanipalya Forest Campus, Vinayakanagar Circle
J.P Nagar, 5th Phase, Bengaluru-560078, Karnataka

The Study Team

Sl.No	Name	Designation
1	Shri. T. Balachandra	Project Coordinator
2	Dr. Tanzeem Fatima	Research Scientist
3	Dr. Sandeep B.N	Research Scientist
4	Ms. Kumuda K.B	Research Associate
5	Ms. Megha M	Research Associate
6	Ms. Ajitha Berty S	Technical Assistant
7	Mrs. Shalini D	Technical Assistant
8	Mr. Satish Birajdar	Field Assistant
9	Mr. Shankarappa	Field Assistant
10	Mrs. Ashwini G	GIS Scientist
11	Mr. Shivaraj	GIS Assistant

Published By

Environmental Management & Policy Research Institute (EMPRI)
Department of Forest, Ecology and Environment, Government of Karnataka
'Hasiru Bhavan', Doresanipalya Forest Campus, Vinayakanagar Circle
J.P Nagar, 5th Phase, Bengaluru-560078, Karnataka

First published by EMPRI Karnataka (India), 2022

Acknowledgements

Environmental Management and Policy Research Institute (EMPRI) is thankful to the Government of Karnataka, Additional Chief Secretary to Government, Forest, Ecology and Environment Department, Principal Chief Conservator of Forests and Head of Forest Force for entrusting the task of conducting the study with regard to 'Impact Assessment of Downhill Pipe Conveyor on Ambient Environment'.

I sincerely thank Chief Conservator of Forests, Ballari, Deputy Conservator of Forests, Ballari and their staff for their valuable support during the study. I sincerely thank M/s. JSW, Ballari for funding this project and Environment Department of M/s. JSW for extending all logistics and necessary support throughout the study.

I sincerely thank Shri. Vipin Singh IFS Director EMPRI, Dr. K.H Vinaya Kumar IFS (R) Director (Research) who as the internal experts have given their valuable inputs throughout the study. I sincerely thank Shri. T Mahesh, Chief Environmental Officer, KSPCB & Director (Technical), EMPRI for his valuable inputs, providing necessary assistance from KSPCB. I also sincerely thank Shri. N. Mohan Karnat IFS (R) and Shri. T. Balachandra IFS (R), Project Coordinators for providing valuable inputs and coordinating the study throughout.

I sincerely thank the study team and external subject expert Shri. M. Sekar for the valuable scientific inputs.

I would like to put on record my gratitude to every member of the team who have worked in pandemic and during the period of study. I also thank all the technical and non-technical staffs, who have directly or indirectly contributed towards the study.

Director General
EMPRI

Abbreviations

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
DOS	Department of Space
E	East
ERDAS	Earth Resources Data Analysis System
FC	Forest Clearance
FCC	False Colour Composite
g/cm3	Gram per centimetre cube
GIS	Geographical Information System
GM	General Merit
GPS	Global Positioning System
GWQI	Ground Water Quality Index
H_2SO_4	Sulphuric Acid
ha	Hectare
HDPE	High Density Polyethylene
HNO_3	Hydrochloric Acid
HOFF	Head of Forest Force
IEC	Importer - Exporter Code
IIHR	Indian Institute of Horticultural Research
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
m/s	Metre per second
Max	Maximum
meq/100g	Milliequivalent per hundred gram
mg/kg	Milligram per kilogram
mg/L	Milligram per Litre
Min	Minimum
$\mu g/m^3$	Milligram per metre cube
µS/cm	Microsiemens per centimetre
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
S	South
Sat	Satellite
SC/ST	Scheduled Caste/Scheduled Tribes
SIA	State 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

TORs	Terms of References
VVVF	Variable Voltage Variable Frequency
W	West
WHO	World Health Organisation
WQI	Water Quality Index
WQR	Water Quality Ratings

Table of Contents

1 Introduction

1.1 Need for the Project

M/s JSW Steel Limited is transporting Iron ores from various mines to Vijayanagara steel plant using a closed pipe conveyor system called Main Pipe Conveyor (MPC) since 2019. These pipelines are located downhill, parallel to roadways and traditional trucks carry ores from mines to feed in MPC. M/s JSW Steel Limited has planned to connect three mines with MPC using a downhill transport mechanism called Downhill Pipe Conveyor (DHPC).

The construction of DHPCs involves diversion of 85.252 ha forest land which includes 15.981 ha of Sandur Taluk's forest land. However, 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. One of such conditions state that - **Condition no 10:** *"The user agency shall conduct a study, at its cost, involving a reputed Institute on the impact of downhill pipe conveyor on the ambient environment"*. As per the stipulated conditions, a decision was taken by the State Forest Department to entrust the task of undertaking ***"Impact Assessment of Downhill Pipe Conveyor on Ambient Environment"*** of Ballari district to 'Environmental Management and Policy Research Institute' (EMPRI) for a period of five years *Vide* letter reference No. KFD/HOFF/A5- 1(MNG)/46/2018-FC-Karnataka Forest Department, Dated 27/07/2020 enclosed as Annexure – I. To carry out the studies Memorandum of understanding has been signed between EMPRI and JSW is enclosed as Annexure – II.

1.2 Description of DHPCs

1.2.1 Pipe Conveyor System

Applications of pipe conveyor belts is a perspective trend in the transportation of mining and agricultural enterprises, an attempt in this sphere has been started as early as in 1970s (Maksarov et al., 2017). Most countries around the world were introduced with substantially strict measures for environmental protection which facilitated the intensive development of closed-type technologies in the transportation of goods. A flat belt passing through the end-face cylinder is gradually folded and attains a cylindrical pipe form with the help of the specially-positioned rollers at one section. Technological processes in the mining industry include various raw material transportation operations which consume significant amounts of energy and generate a substantial share of overall mining costs (Krol et al., 2017). The belt conveyor systems can transport all forms of ores. They cover a wide range of applications, from mining to manufacturing plants where they move materials over long distances, passing through undulated terrains and curves. BBC News (2011) reported the world's longest belt conveyor which conveys phosphate ore over a distance of 98 km from Bou Craa, in the interior of Western Sahara, to the Atlantic seaboard. In view of such examples, M/s. JSW steel limited in Karnataka has adopted a closed belt conveyor system for the transportation of Iron ore for the first time in the year 2019.

1.2.2 Downhill Pipe Conveyor

The downhill pipe conveyor is an elevated transportation method used for moving Iron ores from uphill to downhill. A flat rubber belt is rolled using idlers which are circular in structure and evenly spaced throughout the length of the conveyor to ensure that the belt remains closed. When the pipe reaches the loading or unloading point, it reopens. The operation is identical to that of standard pipe conveyors, with the exception of loading and unloading points at different elevations uphill and downhill respectively.

In pipe conveyor, all drive motors start simultaneously on a load sharing basis through the Programmable Logic Control (PLC) system provided for the intended purpose. The speed control for the drives is achieved through Variable Voltage Variable Frequency (VVVF) units. The signal for starting of motor is transmitted through Optical Fibre Cable (OFC), installed along with the belt pipe conveyor structures from head to tail end. The entire stretch of downhill pipe conveyors, works in this method. Specified dynamics and mechanics of the DHPCs are as follows.

1.3 Components of the DHPC

1.3.1 Idler (Carrying and Return), PSK modules

Pipe Shape Keeping (PSK) idlers consist of a roller, roller brackets, and a module with a support frame. The number of rollers in each PSK module is 12. The PSK modules are fabricated from the MS plate to IS: 2062 standard. The roller is secured with a bracket through fasteners and locking plates. The roller and bracket assembly is fitted with the module through fasteners. Modules are connected in series through pipes, studs and fasteners to impart adequate rigidity. Provision is made for the adjustment of modules by providing slotted holes. Two types of idlers are used i.e., HDPE idlers and metallic idlers. The idlers are greased and sealed. The bearing housing is made of CRCA steel sheets of 3.15 mm thickness. The pressed steel bearing housing is simultaneously welded on both sides of the tube to form a mono-block construction. The bearings are greased and sealed for life. The spindles of the idlers are made from C-45/Equivalent Grade steel conforming to IS 1570 or equivalent material. The spindles are precision machined following the standard practice. The brackets for the idlers are fabricated from rolled steel sections.

i. **Belting:** The design, construction, testing and performance of the conveyor belt comply with the latest revision of BS/DIN/JIS/IS. Belting is of steel cord and Nylon type, M 24 grade with abrasion-resistant covers on the top and bottom of the conveyors.

ii. **Couplings:** High-speed couplings are used for pipe conveyors and traction type fluid couplings for other conveyors. Low-speed couplings are geared type.

iii. **Belt monitoring system:** A belt monitoring system is provided to monitor the health of the conveyor. As the belt moves, the magnet arrays (mounted on a frame above the belt on the return side) magnetize the steel cords of the belt. The sensor array measures the magnetic properties. In real-time, the information is transmitted via a control box to a remote computer screen while the results appear in the easy-to-interpret image output. By measuring new input against the map record, cord guard detects magnetic discontinuities associated with cord gaps; cord ends damaged or deteriorated cords and alerts the operator. Components of pipe conveyor are given in Figure 1.1.

	
Idlers	**Moving belt system**

Casing provided for the moving belt system

Figure 1.1 Components of Pipe Conveyor

1.4 Study Area Description

The study area is three DHPCs i.e., from individual mines to common Main Pipe Conveyor connecting to Vijayanagara steel plant as per the conditions stipulated by MoEF&CC in Stage – I Forest Clearance. The name of DHPCs is as follows.

- Devadari Downhill Pipe Conveyor
- Tunga & Bhadra Downhill Pipe Conveyor
- Rama Downhill Pipe Conveyor

The details of DHPC length considered during study and details of type of land required to construct the same are given in Table 1.1 and 1.2 respectively.

Table 1.1 Details of individual mines

Sl No	Name	Name and length (m) of the DHPC	Phase of work
1	M/s Devadari Iron ore mines	Devadari – 933.01	Construction completed
2	M/s Tunga & Bhadra Iron ore mines	Tunga & Bhadra – 4175	Under construction
3	M/s Rama Iron ore mines	Rama – 6452	Construction not yet started

Table 1.2 Details of forest and non forest area

Sl No	Name	Forest area (ha)	Non-forest area (ha)	Status
1	M/s Devadari Iron ore mines DHPC	0.971	0.219	Construction completed
2	M/s Tunga & Bhadra Iron ore mines DHPC	1.096	3.913	Under construction
3	M/s Rama Iron ore mines DHPC	13.16	2.942	Construction not started

The study area map consisting of all three DHPCs are given in the Figure 1.2.

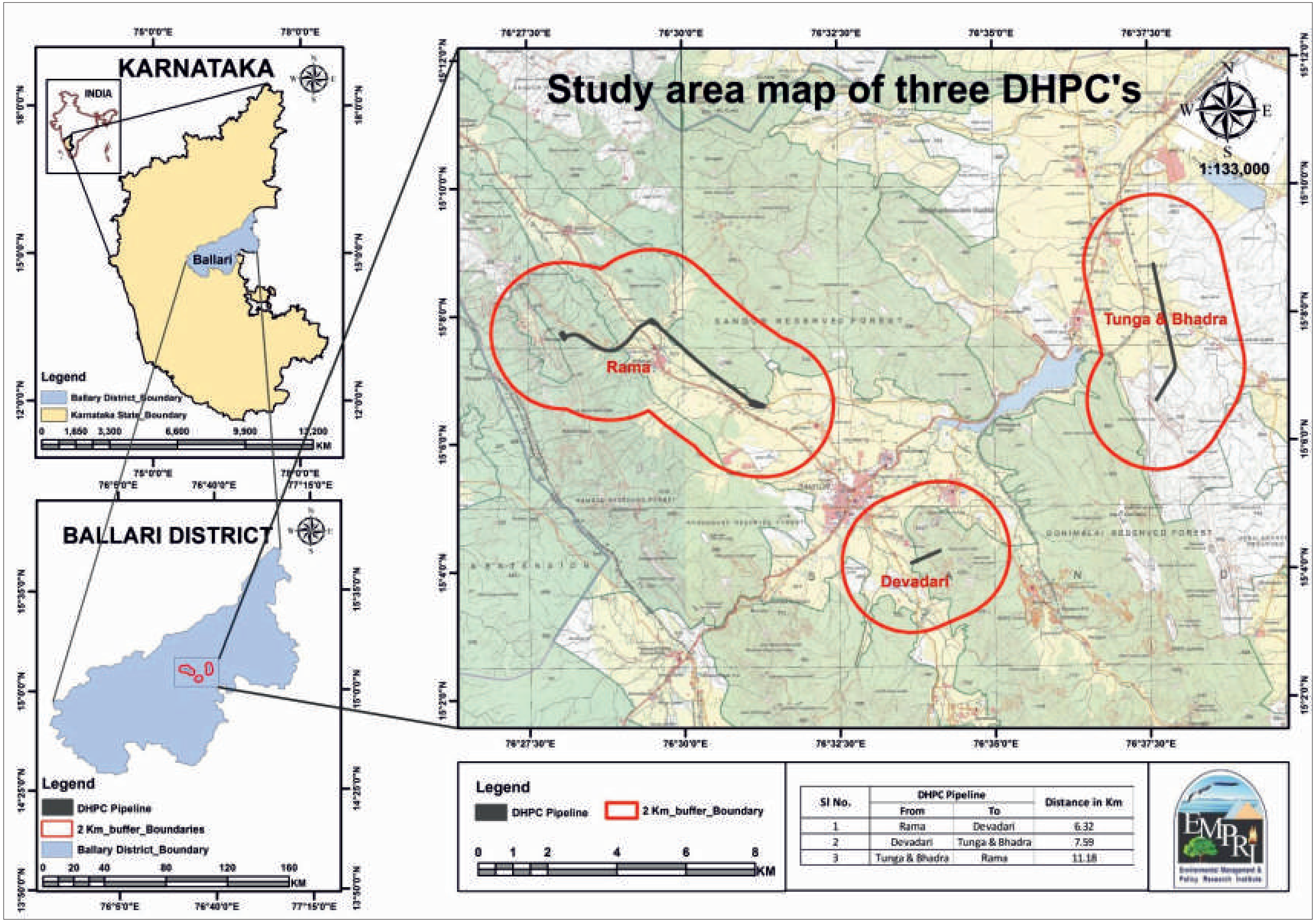


Figure 1.2 Study area map of all three DHPCs

1.4.1 M/s Devadari Iron Ore Mines DHPC

Devadari mine is located in the Swamimalai block of Sandur South range. Devadari DHPC is constructed to carry Iron ore from the Devadari mines (JSW) to Devadari transfer point which connects to the Main Pipe Conveyor (MPC). The length of this DHPC is 933.01 m. based on the land utilization. Devadari DHPC can be classified into 4 segments.

- Segment in the forest area (in existing mine lease)
- Segment in the forest area
- Segment in non-forest area
- Segment in forest area, overlapped with roads

As a whole, Devadari DHPC is in a total area of 1.190 Ha. The extent of forest area is 0.971 Ha which includes 0.048 Ha of existing mine lease and 0.069 Ha of existing proposed services and roads. Devadari DHPC is a steep pipe conveyor 933.01 m with hopper point located at the top of the mine where Iron ores are transferred to the pipe conveyor. The steep pipe connects to the Main Pipe Conveyor (MPC) at transfer point of Lakshmipura village. The study area map of Devadari DHPC is given in Figure 1.3.

1.4.2 M/s Tunga & Bhadra Iron Ore Mines DHPC

Tunga and Bhadra mine is located in the Donimalai block of Sandur North range. Tunga & Bhadra are two mines, vertically separated from each other with Tunga mine located at the top. Tunga and Bhadra DHPC hopper point is planned at the lease area of Bhadra mine. The length of the DHPC is 4175 m. Based on the land utilisation, Tunga and Bhadra DHPC can be classified into 3 segments.

1. Segment in the forest area (in existing mine lease)
2. Segment in the forest area
3. Segment in non-forest area

As a whole, the DHPC is situated in a total area of 5.009 Ha. The extent of forest area is 1.096 ha including 0.492 Ha of existing mine lease. The steep pipe connects to the Main Pipe Conveyor (MPC) at Bannihatti transfer point near Bannihatti village. The Tunga & Bhadra DHPC is in construction stage. The study area map of Tunga & Bhadra DHPC is given in Figure 1.4.

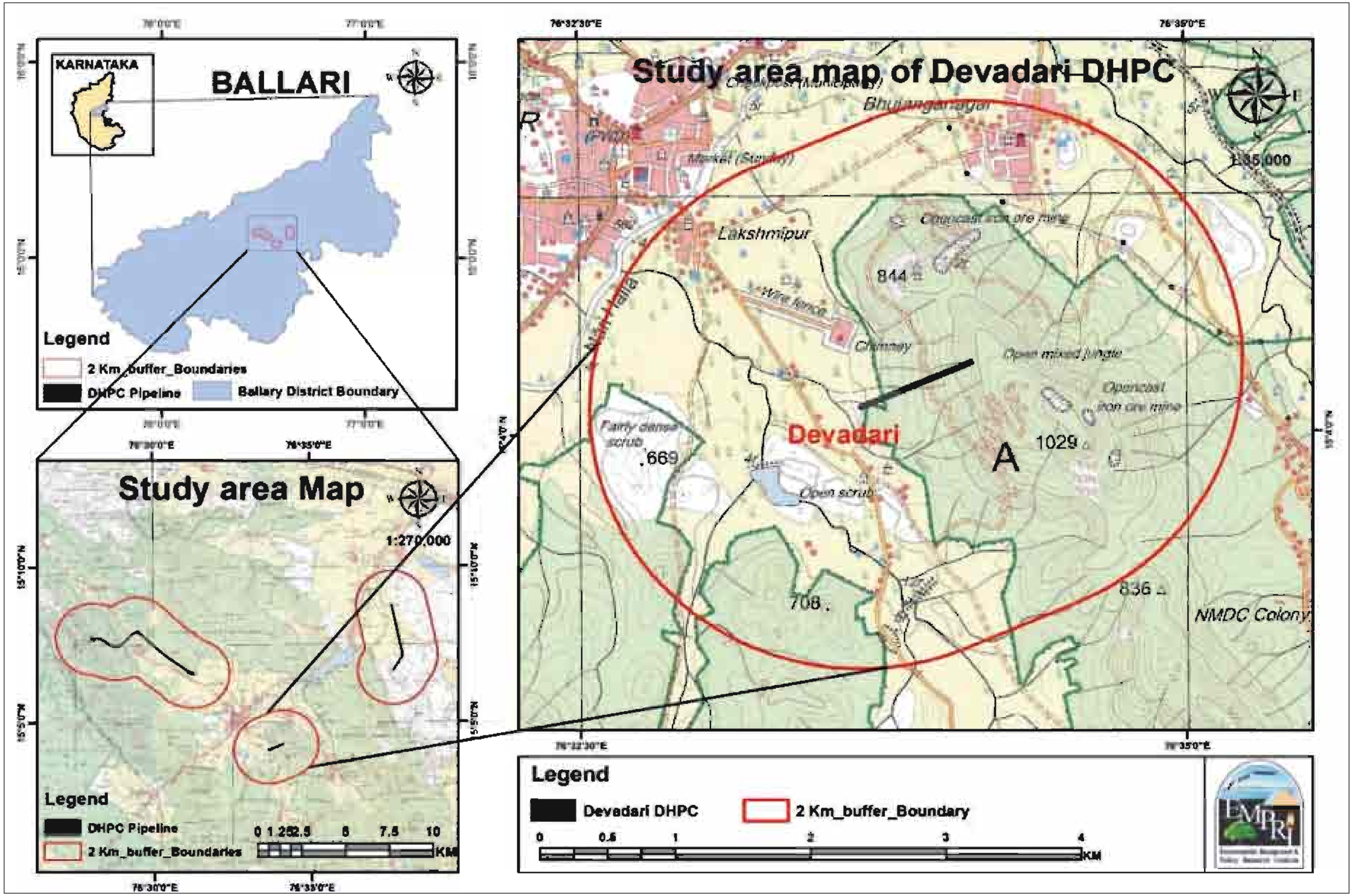


Figure 1.3 Study area map of Devadari DHPC

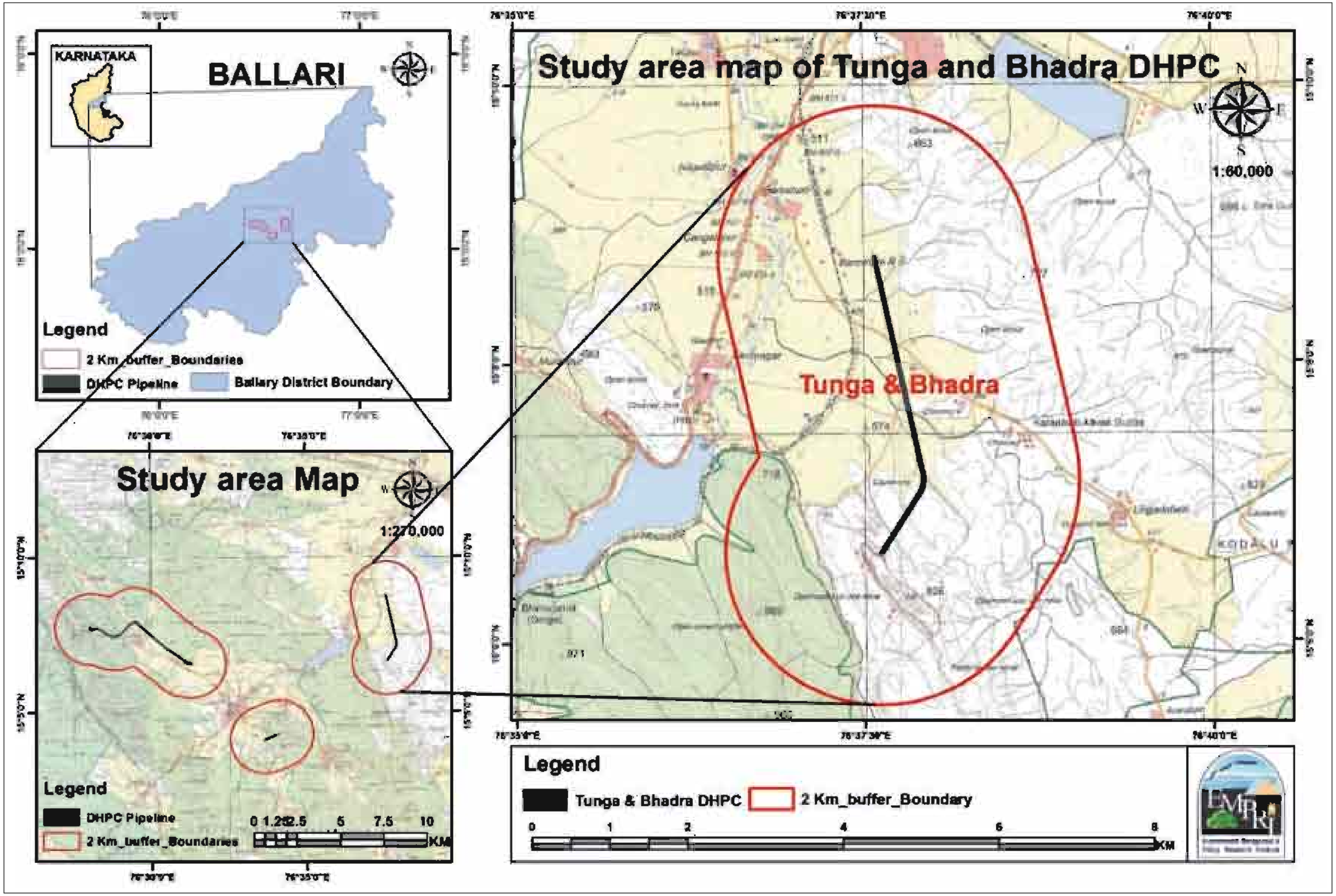


Figure 1.4 Study area map of Tunga & Bhadra DHPC

1.4.3 M/s Rama Iron Ore Mines DHPC

Rama mine is located in Ramanamalai block of Sandur South range. The proposed hopper point is located near the mine lease area. The length of the DHPC is 6454 m which consists of two transfer points, one is located near Sushilnagar village and another is near Doulatpura village. Based on the land use, Rama DHPC can be classified into 2 segments

1. Segment in forest area
2. Segment in non-forest area

As a whole, the DHPC requires a total area of 16.103 ha of which 13.161 Ha is forest area and 2.942 Ha is non-forest area. This DHPC is proposed but construction has not initiated yet. The study area map of Rama DHPC is given in Figure 1.5.

1.5 Terms of References (TORs)

Following are the ToRs accorded by Karnataka Forest Department for assessing the impact of DHPCs on various environmental attributes, during the construction and operation phase.

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. Land use and land cover pattern analysis would be done by using time-series satellite imageries of the selected study area.
VIII. Socio-economic survey (Assess the socio-economic conditions of the people in the project influenced village).

*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.

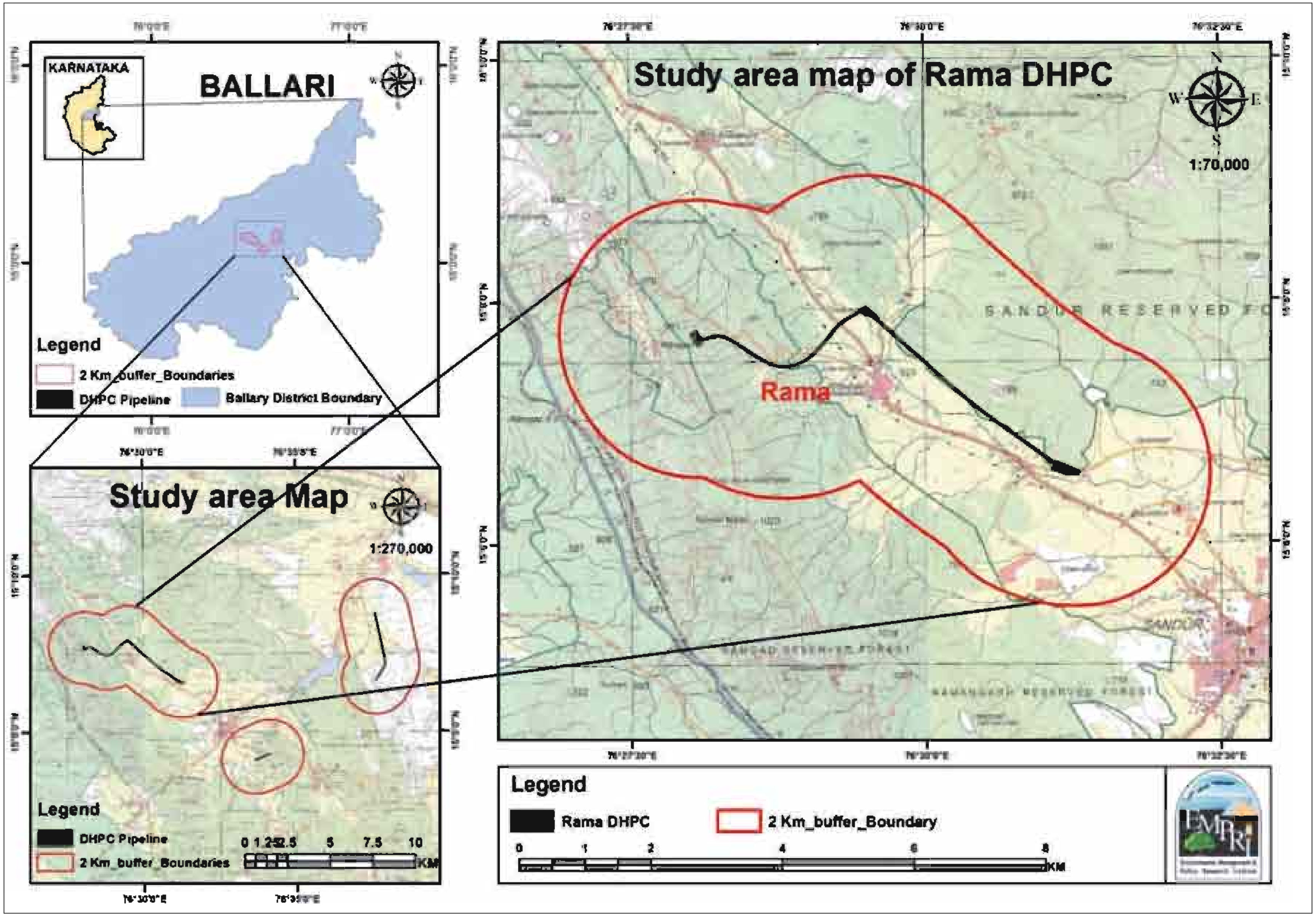


Figure 1.5 Study area map for M/s Rama Iron ore mines DHPC

1.6 Details of study progress

The study was commenced from January 2021 with recruitment of staff. A preliminary site visit was done, under the guidance of environmental consultant to understand the field conditions and identify monitoring locations. The premises of all three mining areas were visited, which are the source of DHPC. Considering EIA guidelines as a thumb rule, study area of 10 km radius was considered from the mid-point of each conveyor. The 10 km study area was demarcated as core (first 5 km radius) and buffer zone (later 5 km). Based on which water and soil samples were collected from each study area in the month of April 2021 from the core zone. However, due to unavoidable circumstances like lockdown due to pandemic COVID during late April 2021 to June 2021 field studies were not executed. The period of lockdown was utilised for literature review and methodology. Under the said circumstances the field study and collection of air and noise data couldn’t fit into the seasonal chart. Sampling of air and noise was carried out after lockdown but due to seasonal rainfall it couldn’t be continued waving off the season. Secondary data was utilised for inventorization of water bodies and meteorology. This is considered as Season I of 2021**.**

During lockdown the need for 10 km radius became debatable. As the impact, beyond certain distance is cumulative from the mines and road transportation rather than DHPC. And the Terms of Reference specifically mentioned the corridors of DHPC for monitoring. Considering these aspects, the concept of buffer and core zone was dissolved and the study area was narrowed to 2 km radius along the linear pipe structure. This study area is considered for air, water, soil and noise monitoring. Since socio-economy is interconnected with a large concept, the study area of 10 km radius was considered for Socio Economic studies.

Considering the updation of study area, samples were collected from 2 km radius for water, soil, air and noise monitoring. Inventorization was carried for 1 km radius as per the Terms of References. Based on the above said constraints and field conditions, following are the details of seasons been monitored and in further chapters the results are presented considering the same:

i. Season I (April 2021 to September 2021)
ii. Season II (October 2021 to January 2022)
iii. Season III (February 2022 to April 2022)

2 Review of Literature

2.1 Pipe conveyors

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

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 under this study is made of high-density polyethylene.

Fedorko (2010) reported about 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 carry 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 pipe conveyor are located on the moveable gears and also it proves definite limitations of this system of material transport. The Koch and Tu Company developed the conceptual design with help of Computer Aided Design (CAD) system, 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 about different types of belt conveyors and provided information about 15 various types of belt conveyors used in mining. In open-cast mining system, variety of conveying systems were necessary, uphill conveying at steep angles and downhill conveying, as well as a variety of material sizes and suitable for long hauls through challenging terrain. The use of a closed belt conveyor reduces pollution, material spillage and protects materials from rain, dust, wind and temperature. Conveyor will not work for irregular sized materials. The maximum conveying angle in uphill is 30° and in downhill is 18° which is observed during completely filled conveyor. Closed pipe conveyor system is guided by six idlers which are arranged in hexagonal shape in every frame. Belt conveyor reduces the environment pollution and transportation cost.

Buchanan (1985) presented in International Materials Handling Conference (IMHC) about the evolution of closed pipe conveyor, sizes of belt, idlers and other components of 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 conveyor system to promote dust free environment, to prevent material spillage and to increase the limitations of inclination and curve angles. In 1979, Japan Pipe Conveyor (JPC) Company installed two pipe conveyors in Japan with pipe diameter of 300 mm, length of 20 m and 28 m respectively. Based on these standard sizes, minimum distance for making belt into pipe shape is 25 times the diameter of the pipe conveyor. Spacing between two idlers frame (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 m^3/hr, and speed varies from 1 to 4 m/s. Along with all these details, Japan Pipe Conveyor (JPC) Company has mentioned about belt formation and its strength, idlers sizes and supporting structure.

2.2 Inventorisation of water bodies

Water is an essential resource of livelihood. Water bodies are the places of accumulation of water on the surface of earth. Earth supports a large and fascinating variety of water bodies. Surface water bodies are essential water storage units and play an important role in 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, all irrigation tanks, river reaches where lifting is possible (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 change in climate, land use, or vegetation. Lakes are the third general type of water bodies. 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

2.3.1 Surface water

The research study of surface water quality of Sandur schist (medium-grained metamorphic rock) belt in and around, was carried out by (Goankar et al., 2016). Total 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 the erosion/wash-off during rainy season which in turn increased the Iron content in surface water bodies.

Madhukar and Srikantaswamy, (2013) carried studies in industrial area near Bidadi which has Vrishabhavathi reservoir. This reservoir receives water from Vrishabhavathi River that flows through Bengaluru city and carries effluent; wastewater from STP’s 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) of 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 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. Total 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, 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 Mallathahalli lake sample for domestic and irrigation purposes. But, both the lake water require certain degree of treatment for further usage. To understand about the sampling procedures and parameters being analysed, this paper was reviewed.

Shukla et al., (2011) conducted studies near Kanpur industrial area along the right bank of Ganga River. Twelve water samples were collected and seven major water quality parameters were analysed considering the examination procedure from APHA manual. Five beneficial classes were considered and WQI limits were prescribed to it. 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 excellent category but they ranged between good to unacceptable. Due to severe contamination, the total coliform was detected in the stretch and this resulted in poor and unacceptable water quality range. This literature gives information on the standard methods to be referred and the standards to be compared with. Hence, this paper was reviewed.

2.3.2 Groundwater

Groundwater quality of Sandur Taluk, Ballari has been investigated (Thotappaiah et al., 2019). Fifty locations were selected for groundwater sampling and 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 summer and rainy season, Groundwater samples showed similar Cations (Calcium>Sodium>Magnesium>Potassium) and Anions (Chloride > Bicarbonate > Sulphate) pattern whereas in winter season Cations (Calcium > Magnesium > Sodium > Potassium) pattern varied but Anions (Chloride > Bicarbonate > Sulphate) pattern remained same. The groundwater quality was deteriorated due to presence of 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.

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, 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 Central part (Narihalla, Sandur, Bhujanganagar, Doulatpura, Sushilnagar, Krishnagar and Dharmapura Village) followed by 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 system. 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 constructions. As impact during construction is important this study was considered and reviewed.

Kumar et al., (2012) assessed the surface and groundwater quality of Sandur. The study was conducted during monsoon period (June - August, 2011). Experimental results showed an 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.

Suresh et al., (2009) assessed the groundwater quality in and around Ballari city. Samples were collected in the post monsoon season (Year 2007) and analyzed 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 analyzed have revealed that the water is not good for domestic use and can be used for irrigation purpose with proper water treatment. The parameters being analysed are similar in the present study hence, to understand approach and methodology this literature was reviewed.

2.4 Ambient air quality

Air quality modelling of Iron ore mines of Saranda (West Singhbhum), Jharkhand has been reported (Chaulya et al., 2019). The study was carried out during winter season (December 2015 - February 2016) and 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 permissible limit (National Ambient Air Quality Standards) due to Iron ore transportation by trucks. Air quality modelling study revealed that the Iron ore transported through closed conveyor belt reduced the air pollution in Saranda region.

Ambient air quality of Khondbond Iron ore mines, Orissa has been assessed (Shrivastava et al., 2018). The study was conducted for 24 hours at four locations (Near plant, mining site, near 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 were below permissible limits (National Ambient Air Quality Standards). Higher Particulate Matter-10 (PM_{10}) concentrations were recorded near plant and mining site due to excess vehicular movement and mining activities. Finally, it was suggested to adopt conveyor system for transportation of Iron ore in order to reduce the air pollution.

Singh and Perwez, (2015) reported the ambient air quality of Iron ore mines of Goa. Selected thirty four locations were monitored for 24 hours from January 2011 - December 2012 during summer, post monsoon and winter season. Results have revealed that Particulate Matter - 10 (PM_{10}) as major air pollutant with higher concentration was observed in transportation routes followed by mines and buffer zone. Particulate Matter - 10 (PM_{10}) concentration exceeded but Sulphur Dioxide (SO_2) and Nitrogen Oxide (NO_X) concentration were within the permissible limit of National Ambient Air Quality Standards.

2.5 Ambient noise quality

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, 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. Sound parameter of the study area did not assess the direct impact on the human health. Pertaining to the faunal study, species may get affected by the sound.

Ladanyi, (2016) researched on noise of belt conveyor rollers. As per the studies the noise generated was mainly due to continuous transportation and linear nature of source. The combined operation of noise generating mechanisms such as roller bearing and its vicinity, contact of roller and belt, 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 installation of conveyor is expensive. So intervention in design phase is suggested and also the accurate noise outputs during design phase need to be estimated for reliable sound propagation. The noise levels of 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 increase in belt velocity has a less effect on noise increase.

A belt conveyor constitutes a linear sound source. Sadowski and Fas, (2014) presented the acoustic work of a coal transporting conveyor belt which 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 through this study. A multilayer sound absorbing and insulating system was constructed in a section of 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 ground. The layers included absorbing plate, three sound proofing plates, insulation board, anti-corrosive plate, 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 installation of the insulation screen, noise level reduced in the protected area to below the permissible limits compared to unprotected zones without insulation screen. Such insulating layer can be adapted to reduce the noise impact.

Sadowski, (2005) studied the noise and its minimization in Iron foundry at PESA plant in Bydgoszcz. A study on the influence of noise on health condition of employees was undertaken and compared with their work efficiency. Unlike an individual conveyor Iron foundry have many source of noise (including 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 range higher than 35 dB (A), resulted in low productivity, difficulty in sleeping and hearing impairment of the employees. 1dB (A) reduction of noise than the average noise range reduces number of accidents, injuries by 10%. Considering all these, noise reduction implementation such as sound proofing, sound absorption materials were used, tested and found to increase employee productivity 23%. The study concluded by providing an economical, medical and ecological significance of noise minimization. Although this study was observed between employees, impact produced will be similar on every individual health degradation and productivity in case of downhill pipe conveyor because it passes through many villages in close range.

2.6 Soil Quality

Working plan of Ballari Forest Division, Karnataka, mentions about 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 Ballari district. The black soil is present over wide stretches of land in Ballari and Hadagali taluk's. Reddish sandy loam is present in Sandur Taluk. The reddish brown soils present at the fringes of the hills 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 high concentration of soluble salts, which is critical for germination and growth. The available potash is wide spread from very low to very high grades. In this context the need for application of phosphate fertilizers is to be examined. The black soils contain 68% clay and are rich in lime. Its properties of retaining moisture, of 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, Western fringes of Swamimalai and Devagiri plateau in Sandur North and South ranges and 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 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 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.

2.7 Meteorology

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 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 downhill pipe conveyor study.

Gowda et al., (2015) studied the concentration and distribution of Particulate Matter in 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 had 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) was observed in the rainy season. Results have 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. Meteorological data of this study area is useful for the interpretation of Devadari downhill pipe conveyor meteorological conditions since Subbarayanahalli Iron ore mine is located close to Devadari Iron ore mines.

2.8 Socio-economic survey

Umar et al., (2021) presented a study on environmental and socio-economic impact of pipeline transport interdiction as oil pipelines were constantly interdicted by aggrieved individuals in Nigeria. Pipeline interdiction affects the process of oil and gas production and transportation, thereby affecting the state of the economy of any nation where it is prevalent. An estimate of about 80-90% of oil and gas revenue contributes to Nigerian government's revenue. The major contribution of the study was to adopt a forensic approach to provide an in-depth oil spill occurrence analysis and to explore the link between the interdictions resulting in oil spills and the economic, health and environmental impacts. The study concluded that, environmental and socioeconomic impacts of third party interdiction affect sustainable production of oil and gas in Nigerian Delta. The spill data analyzed had revealed that 60% of oil spill of the region was due to interdiction. Failure to adhere strictly to the standards of maintenance and slow response to spill incidences are responsible for spills due to operation failures. These spills including third party interdiction and slow maintenance cumulatively made significant damage in human health and ecosystem within 13 years equally affecting Nigeria's economic growth, increased poverty level, unemployment and underemployment. This study stays as an example of how a negative economic impact on mob eventually results in overall negative impact of a country.

Mining is a major economic activity which prospers companies, government and workers. But the environment and health effects aren't negligible. Kumar and Basavaraj, 2020 reviewed the health status of mining labourers in Ballari district. The study was carried out using primary data like questionnaire, interview, case study 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 high incidence of lung infections, heart problems and dust inhalation. Generation of dust due to loading and unloading of ore and vehicular emission are all a part of transportation pollution. About 95% of industries located in Ballari are predominantly polluting air. The major polluting industries are found to be mining, Iron ore processing industries and Steel industries and all these industries use significant amount of road transportation which also overburdens the infrastructures. The NH13 and state highways are in poor condition due to 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 leads to loss of feeling, dangerous infection 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 tear off social fabric, increased personal stress and mental health problem throughput community. The transportation pollution on air will be significantly reduced by adapting pipeline. 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 socio-economic impact of mining and mining policies in Vindhyan region of Uttar Pradesh (Dubey, 2017). Three districts in Vindhyan region including Allahabad, Mirzapur and Sonbhadra where various mining activities occur were chosen as study area. The socio-economic profile and impact of mining in soil and vegetation of all these three districts were reported in the study. It was performed by using 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 forest, impact of mining in forest area, awareness of forestry program and mining policies, dispute in mining, presence of illegal mining, dependency of mining for livelihood, type of dependency on mining, effect of closure of mining activity on livelihood, extend of effect on livelihood, health related problems due to mining, safety precautions adopted in mining, effect of mining on agriculture, perception regarding restoration program of each districts are plotted in this report. The study also revealed the impact of mining on flora and soil characteristics. Impact on flora was compared between flora of undisturbed (100 m away from mining site) and disturbed sites (active mining site) of respective mines (stone mine and coal mines). Soil texture and physico-chemical parameters of the same were also carried out.

The questionnaire method used in this study is adapted in assessing the socio-economic impact of pipe conveyor in project influenced area of Sandur Taluk so that a clear socio-economic profile can be drawn.

A clean air plan 2017 was proposed in Bay area air quality management district. The plan had first two goals to protect public health and second to protect climate. Implementing such plan denotes compromise in economic activities. The implementation of the plan will benefit Bay area with air quality, good health and climate and they were expected to be significant but also affect a wide variety of businesses, household and land uses. Many emission sources like stationary source, building control, transportation were identified and their control measure, estimation of cost was provided. Most of the data used was 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 was increased in the region which grew annually by 3.0% between 2010 and 2015. The profession of the population and their individual annual growth was also provided. The economic sector was sore share of total employment. A statistical description of the industry affecting region is prepared by analysing number of establishments, jobs and payrolls. The sales generated and net profit of the industry was analysed. The cost estimated for control measures were compared with net profit of individual industries. The evaluation has revealed that there will be adverse impacts on both private and public sector. 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 social cost of carbon as termed by economist and was found both the health and climatic benefits to the tune of billions of dollars. This is similar to socioeconomic impact assessment of DHPC project as both contribute to the betterment of environment by reducing air pollution but results at the cost of economic compromise.

Civil engineering projects are significant in developing the economy of 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 projects 5 basic methods can be utilized for assessing impact such as checklist, interaction matrices, overlay mapping, network and simulation modelling. For this particular study checklist method was used by (Neba and Ngeh, 2009). The same checklist method was followed for assessing the socioeconomic impact on 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 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) 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 the high medium and low and both positive and negative impacts were observed. In the view of positive impacts, local employment, training and local business development was found to be high. Education project assistance and malaria prevention program was medium and sport facilities, agriculture and tuberculosis patient assistance was on the lower side. While negative impact was considered, damage to crops and farmland, abandonment of project facilities and local attitudes was high. Inequitable distribution of jobs and an inflationary situation was medium. Resettlement of displaced people and damage to cultural and archaeological and religious matters had low negative impact. The study was well structured in terms of components which are followed in impact assessment of DHPC on ambient environment.

2.9 Land use and Land cover

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 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 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 by (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 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, Landsat-8 OLI by using 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 of forest (25.35 km^2), water bodies to (0.94 km^2), agriculture to (98.48 km^2), and road to (10.80 km^2). Increment in the rate of mining area to 100.72 km^2 and grass cover 34.86 km^2 during the study period. Meanwhile 90.18 % overall accuracy and (0.87) kappa coefficient for 1992 classified image, 93.41 % overall accuracy and (0.91) Kappa coefficient for 2006 classified image and 88.69 % overall accuracy and (0.85) kappa coefficient for 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 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 of 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% in1990 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 sub divided based on the area. The author concluded that built area had increased from 6% to 23% while, the forest cover had reduced from 37% to 31% since 1997 to 2017. In present study the LULC studies is initiated to understand variation.

Land use and Land cover change of 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 increase in 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 were 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.

3 Methodology

3.1 ToR – I Inventorisation of water bodies

Inventorisation is a method followed to provide a quantitative data of water bodies present in the area being studied. 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.

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

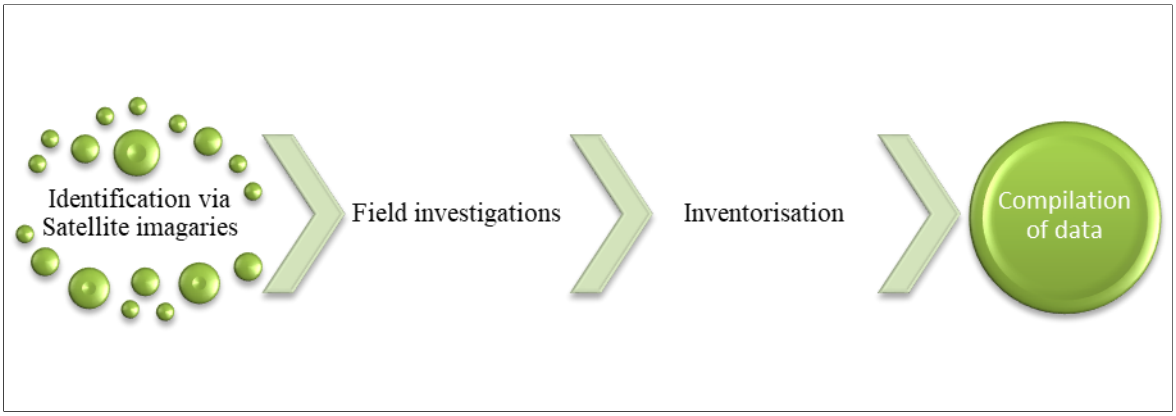


Figure 3.1 Pictorial representation of methodology for inventorisation of waterbody

3.1 ToR – II Surface water & Ground water

3.1.1 Surface water

Surface water is any body of water above ground which includes streams, rivers, lakes, reservoirs, wetlands, creeks etc., Though oceans have saltwater they are considered as surface water. Surface water participates in the hydrologic cycle/water cycle, which involves the movement of water to and from the earth’s surface. Precipitation and water runoff feed surface water bodies. Evaporation and seepage of water into the ground, on the other hand, cause water bodies to lose water. However it will stay in hydrological cycle in different form.

Water quality as a whole is a combination of physical, chemical and biological characteristics of water.

Various literatures were reviewed to understand the sampling location identification and sampling methods. In consultation to subject matter experts, literatures and CPCB guidelines following methodology were arrived for both surface and groundwater sample collection and analysis. Schematic representation of methodology is given in Figure 3.2.

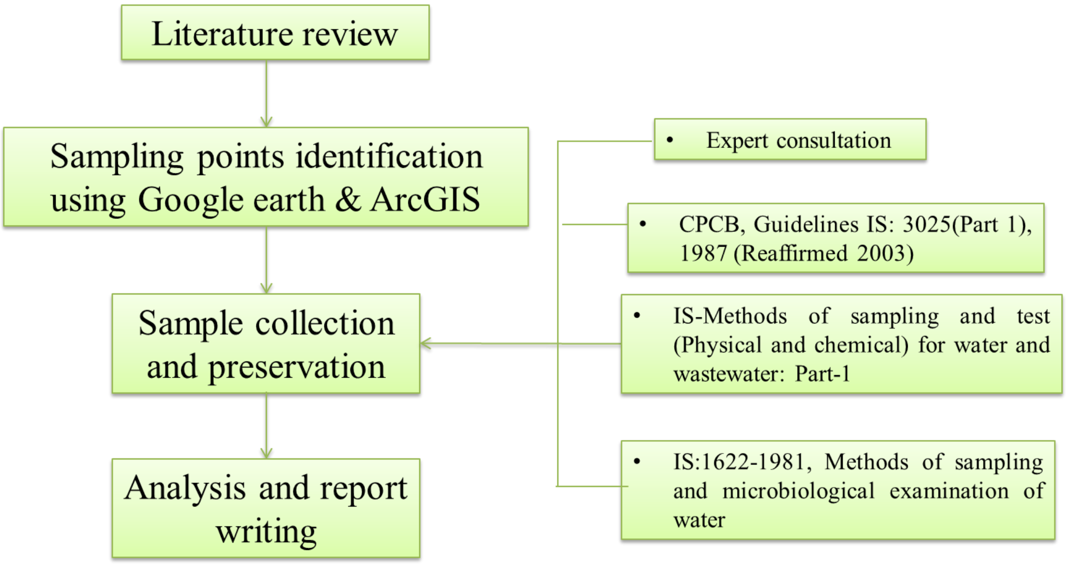


Figure 3.2 Schematic representation of surface water sampling methodology

3.1.1.1 Sampling method

Central Pollution Control Board, in its guidelines for water quality monitoring, specifies about various sample methods like: Grab sample, Composite sample and Integrated sample. Out of these three sampling methods, 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 physical, chemical and biological properties of water has direct impact on the quality of water. To understand the baseline status of water quality in the study area, surface water samples were collected from 5 lakes considering 2 km buffer area around each DHPC, considering composite sampling technique. Surface water samples were collected as per CPCB guidelines.

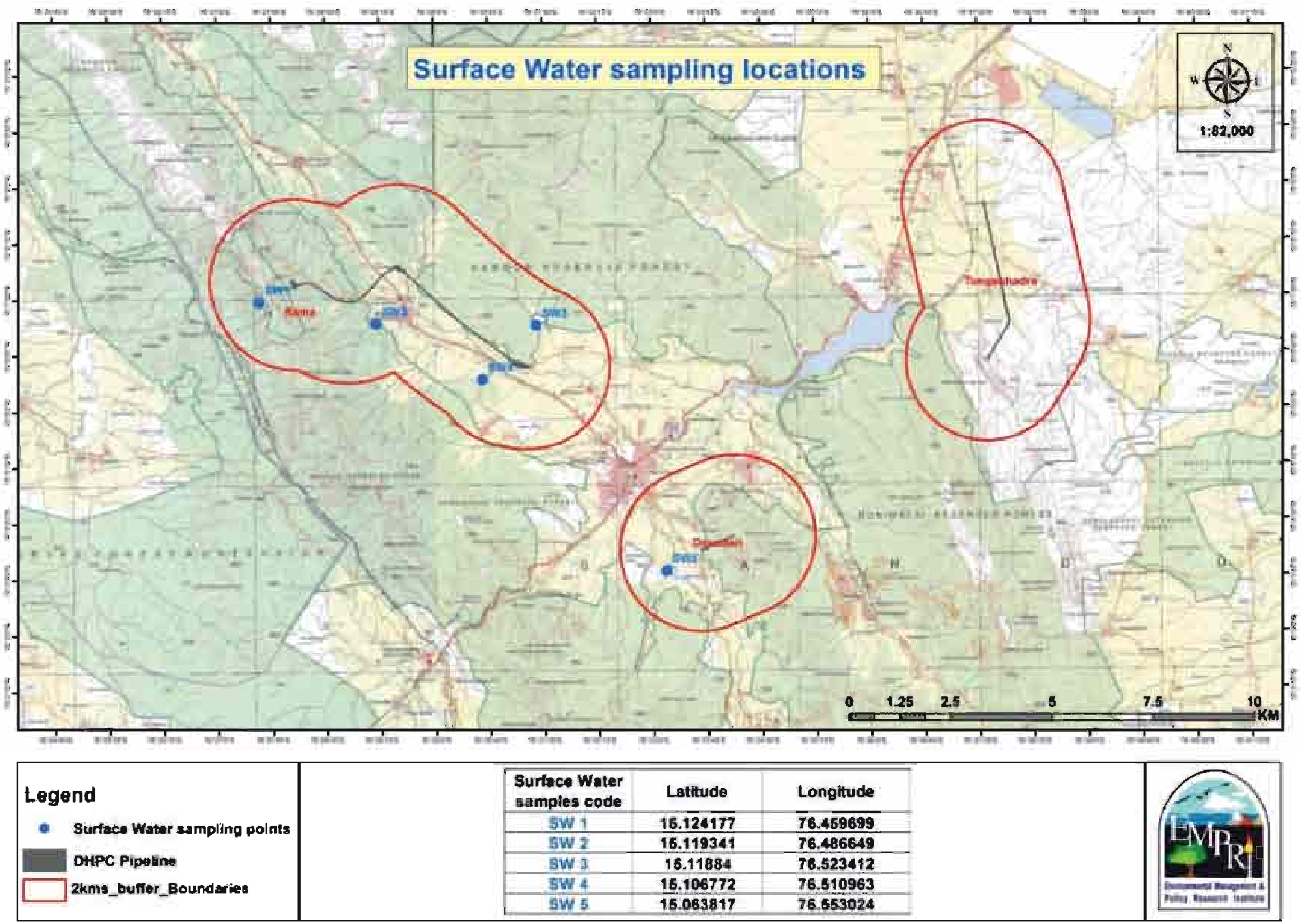
- ➢ The sampling cans were thoroughly washed using Isopropyl alcohol prior to sampling.
- ➢ Sampling was done wearing all the Personal Protective Equipment’s.

- Samples were collected using rope, bucket and were transported in 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 sample for Oil & Grease analysis which were preserved using H_2SO_4.
- Sulphide analysis sample were collected in 1L can containing Zinc acetate and preserved using NaOH.
- Sterilized brown glass bottles were used for collection of microbial analysis.
- The results of the water samples are compared with CPCB's designated water quality criteria to identify the quality of the water body.

3.1.1.2 Sampling details

The surface water quality was monitored during Season I, Season II and Season III. Although the monitoring was done, the sampling locations of Season I differed from Season II and III. One perennial water body was considered for Season I. Later after narrowing the study area based on ToR, a total of 5 surface water bodies were identified for sampling comprising Devadari and Rama study area. The study area was of a 2km buffer along the linear stretch of each individual DHPC. The landscape of Tunga & Bhadra DHPC study area did not have any potential water body for sampling. Similarly 2 water bodies had dried due to seasonal variation in Rama study area during Season III.

Map showing surface water monitoring locations are given in Figure 3.3. List of the surface water sampling locations and the status of monitoring for both seasons are provided in Table 3.1 and the parameters analysed and the methods followed are provided in Table 3.2.



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

Figure 3.3 Map representing surface water monitoring locations

Table 3.1 Details of surface water sampling locations

Sl No	Study Area	Location name	Sample Code	GPS Coordinates	Season I	Season II	Season III
1	Rama mines	Ramgad lake	SW1	15.1241 N 76.459 E	-	Collected	Dried
2		Chinnapankola	SW2	15.119 N 76.48 E	-	Collected	Dried
3		Singanakere	SW3	15.118 N 76.523 E	-	Collected	Collected
4		Kolifarm	SW4	15.106 N 76.510 E	-	Collected	Collected
5	Devadari mines	Hulikunte	SW5	15.063 N 76.553 E	-	Collected	Collected
6		Narihalla	SW1	15.106 N 76.584 E	Collected	-	-

Table 3.2 Parameters analysed and methods followed for Surface Water

Sl No	Parameters	Method followed
1	pH	Electrometric method
2	Colour	Colorimetric method
3	Odour	Threshold odour test
4	TDS	Gravimetric Method
5	Chlorides	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	Phosphates	Stannous Chloride method
17	Sulphide	Iodometric method
18	Residual Sodium Carbonate	Calculation method
19	Total Coliform	Multiple Tube Fermentation Technique

3.1.2 Groundwater

Groundwater is a significant natural resource in present day, 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).

Groundwater is the water present underneath earth's surface in rock, soil pore spaces and in the fractures of rock formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. Water table is the depth at which soil pore spaces, fractures and voids in rock become completely saturated with water. Groundwater is recharged from the surface percolation and through rain water which seeps down.

Various literatures were reviewed to understand the sampling location identification and sampling methods. In consultation to subject matter experts, literatures and CPCB guidelines, following methodology was arrived for both surface and groundwater sample collection and analysis. Schematic representation of methodology is given in Figure 3.4.

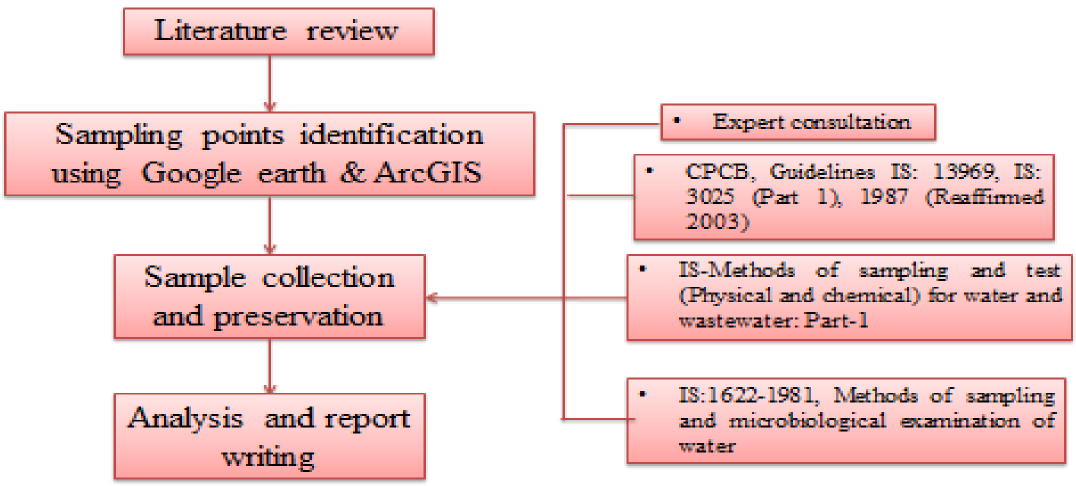


Figure 3.4 Schematic representation of ground water sampling methodology

3.1.2.1 Sampling method

Based on IS: 13969 guidelines for sampling of ground water and suggestions given by environment consultant, sampling from existing boreholes is followed. Any effect on physical, chemical and biological properties of water has 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 prior to 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.

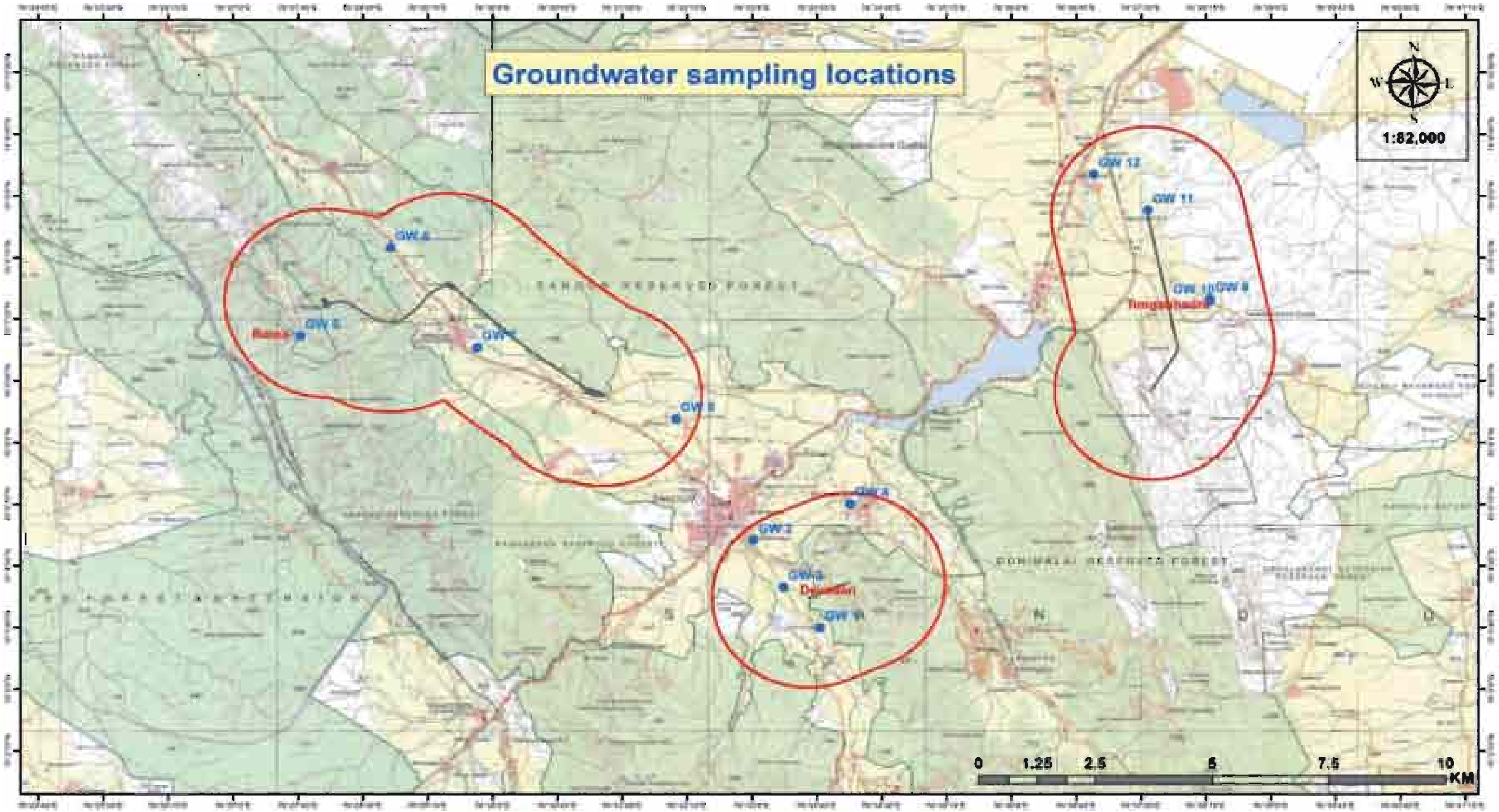
- Heavy metals and hardness analysis samples were preserved with HNO_3 in 2 number of 1 L cans.
- Cyanide analysis samples were preserved with NaOH in 1 L cans.
- Sterilized brown glass bottles were used for collection of microbial analysis.
- Sampling was done wearing all the Personal Protective Equipment's.
- The results of the water samples are used to calculate the Water Quality Index (WQI) using basic parameters in reference to the Acceptable limits of Drinking water standards.
- Based on the WQI the quality of the water is estimated.

The WQI criteria are given in Table 3.6.

3.1.2.1 Sampling details

The ground water quality was monitored during Season I, Season II and Season III. Although the monitoring happened, the sampling locations of Season I differed from Season II and Season III. 10 ground water boreholes were considered for Season I from the core zone. Later after narrowing the study area, 4 ground water boreholes were identified for sampling in each study area covering the stretch. This study area includes a buffer of 2 km along the stretch of each DHPCs. Map showing ground water sampling location of Season II and III is given in Figure 3.5.

Groundwater samples collected varied from season I to II and III, details of sampling locations are given in Table 3.3 and 3.4 for season I and Season II & III respectively.



Legend

- Groundwater sampling points
- DHPC Pipeline
- 2kms_buffer_Boundaries

Groundwater samples code	Latitude	Longitude	Groundwater samples code	Latitude	Longitude
GW 1	15.062371	76.563097	GW 7	15.11921	76.497058
GW 2	15.070578	76.556057	GW 8	15.104732	76.535338
GW 3	15.080062	76.550229	GW 9	15.129003	76.638286
GW 4	15.087491	76.568942	GW 10	15.128597	76.638336
GW 5	15.121633	76.462879	GW 11	15.146943	76.626342
GW 6	15.139387	76.480325	GW 12	15.15426	76.615926

Figure 3.5 Map representing groundwater monitoring locations

Table 3.3 Details of groundwater sampling locations of Season I

Sl No	Study area	Location Name	GPS Coordinates	
			Latitude	Longitude
1	Devadari DHPC	Lakshmipura	15.0780556 N	76.54527778 E
2		Sennibasappa camp	15.08055556 N	76.55166667 E
3		Bhujanganagar	15.08722222 N	76.5630556 E
4		Narasapura	15.05277778 N	76.60000 E
5	Rama DHPC	Ramgad Temple	15.09472222 N	76.57666667 E
6		Siddapura	15.15138889 N	76.47083333 E
7		Sushilnagar	15.12833333 N	76.49055556 E
8	Tunga & Bhadra DHPC	Lingadahalli	15.11611111 N	76.6511111 E
9		Bannihatti	15.155000 N	76.60388889 E
10		Taranagar	15.1333333 N	76.6100000 E

Table 3.4 Details of groundwater sampling locations of Season II and Season III

Sl No	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 3.5 Parameters analysed and methods followed for ground water

Sl No	Parameter	Analysis Method
1	pH	Electrometric method
2	Colour	Colorimetric method
3	Odour	Threshold odor test
4	TDS	Gravimetric method
5	Chlorides	Argentometric method
6	Sulphate	Turbidimetric method
7	Fluorides	SPADAN's Method
8	Iron	AAS
9	Boron	Curcumin method
10	Sodium	Flame photometry method
11	Potassium	Flame Photometry method
12	Aluminium	Yet to be decided
13	Copper	AAS
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

Table 3.6 Details of 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

3.2 ToR III - Air Quality

Air pollution is a major environmental problem in India which has impact on human health, agriculture practices, climate and ecosystem (Nasir et al., 2016). Major sources of Air pollution are industrial and automobile emissions, construction activities, biomass burning, volcanic eruptions, forest fires, dust and desert storms that in turn 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. Particulate Matter - 10 (PM_{10}) is coarse particles with diameter of 2.5 to 10 µm. Major constituents of PM_{10} are organic and elemental Carbon, metals like Silicon, Magnesium, Iron and ions like Sulphate, Nitrate, Ammonium etc. The anthropogenic source are 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.

Particulate Matter – 2.5 ($PM_{2.5}$) is fine particles with 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; aggravate asthma and chronic bronchitis etc.

Nitrogen Dioxide (NO_2) is a reddish-brown toxic gas with a characteristic sharp odour. Major sources include lightning, forest fires, bacterial activity of soil as 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, throat and increase the respiratory infections in humans.

Sulphur Dioxide (SO_2) is a colourless, soluble gas with a characteristic pungent smell. Its natural source is volcanic eruptions and anthropogenic sources are 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).

Air quality deterioration can be minimised, prevented by Air quality monitoring (Singh and Perwez, 2015). In the present study, ambient air quality is monitored in construction and operation phases of downhill pipe conveyor and results are compared with guidelines of CPCB, National Ambient Air Quality Standards (2009).

Based on the CPCB, National Ambient Air Quality Standard (2009) guidelines and suggestions given by environment consultant, the air monitoring methodology and locations were finalised. Ambient air quality was assessed considering 2 km radius of the respective DHPC. Air quality monitoring was carried out at 14 locations comprising of forest area, agricultural land, settlement and sensitive zones (Industries/schools/colleges/hospitals) during post monsoon season. The criteria followed for 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.

The parameters analysed and the method is given in Table 3.8. Particulate Matter - 10, Particulate Matter - 2.5, Sulphur Dioxide and Nitrogen Dioxide were monitored in field for 24 h as per the Central Pollution Control Board, National Ambient Air Quality Standards (2009) guidelines. Particulate Matter - 10 and Particulate Matter - 2.5 concentration was measured by using Respirable Dust Sampler (Greintech Instruments., India, Model GTI 133) and Fine Particulate Dust Sampler (Envirotech Instruments Pvt. Ltd., India, Model APM 550 Mini). National Ambient Air Quality Standard (2009) methods were followed for air sampling, analysis and the schematic representation of the same is shown in Figure 3.6.

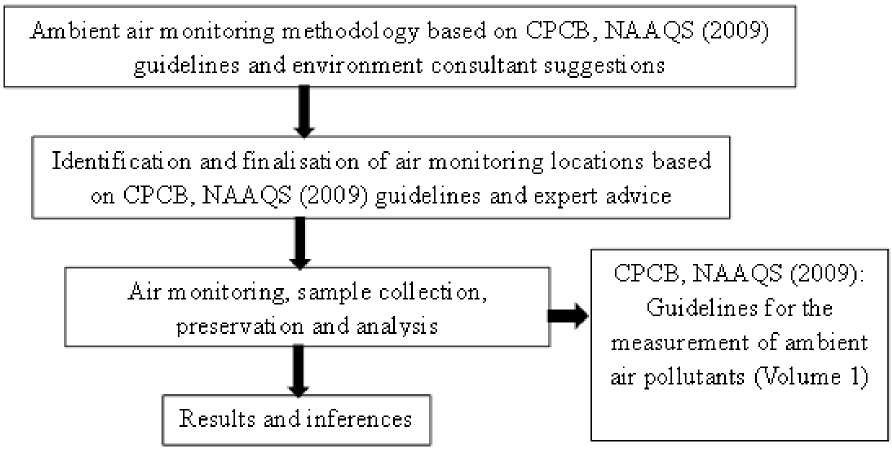


Figure 3.6 Schematic representation of air monitoring methodology

List of air monitoring locations is given in Table 3.7 and map representing the same is given in Figure 3.7.

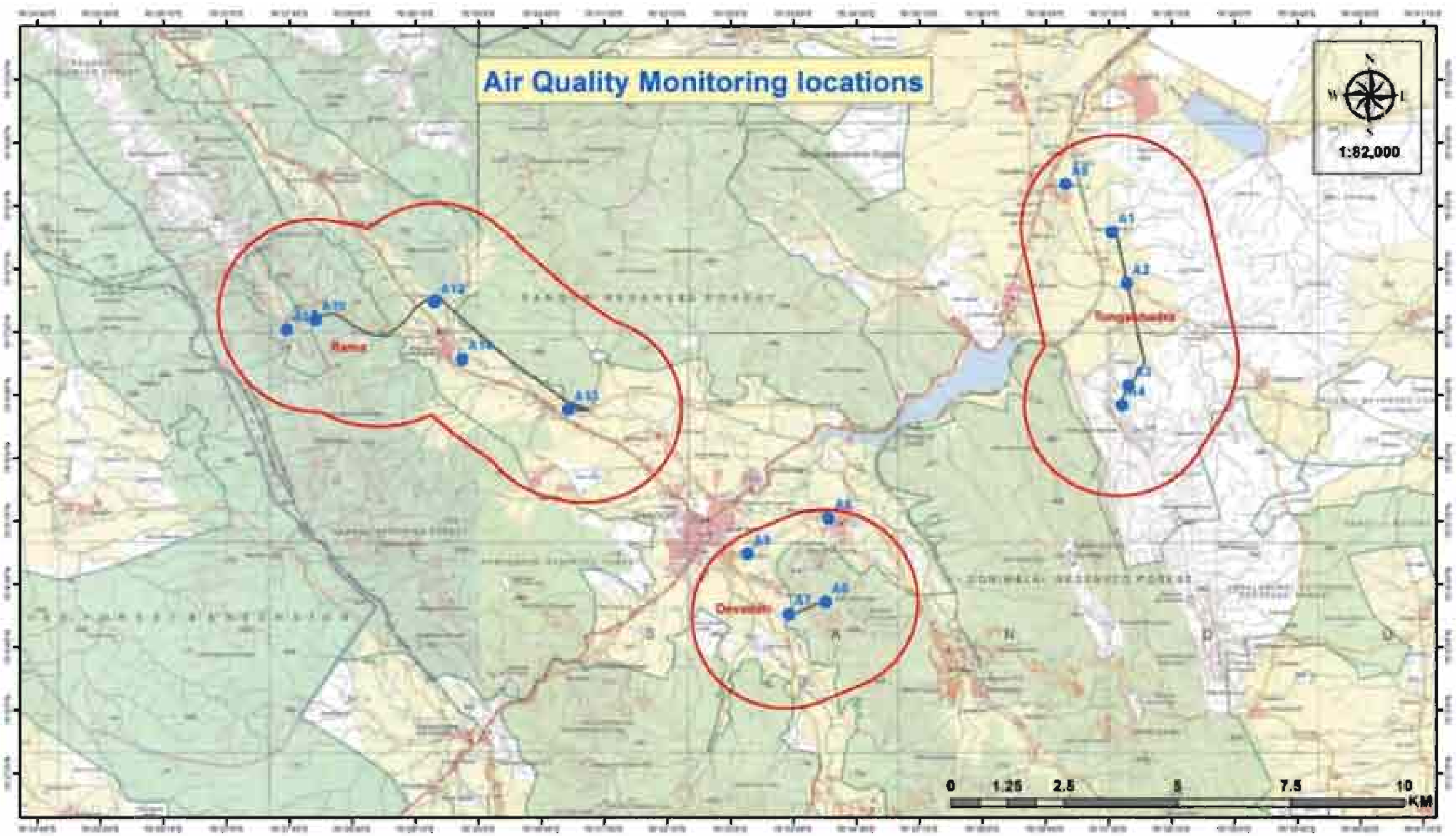
Table 3.7 Details of air monitoring locations

Sl No	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 3.8 Parameters analysed and analysis method for ambient air

Sl No	Parameter	Analysis method
1	PM_{10}	Gravimetric
2	$PM_{2.5}$	Gravimetric
3	SO_2	Improved west & Geake’s
4	NO_2	Modified Jacob and Honchheiser

Based on the results of the parameters analysed, the Air Quality Index (AQI) was calculated. Using AQI the quality of the air was estimated.



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	76.581622	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			

Figure 3.7 Map showing air monitoring locations

3.3 ToR IV - Noise monitoring

The word 'Noise' is originated from the Latin word "nausea" which implies 'unpleasant, unwanted, loud, harsh and unexpected sound. A sound becomes noise when it is unpleasant, unwanted, loud and unexpected which has detrimental physiological and psychological effect on living beings. In general, noise is any sound that humans do not want to hear (Bala and Verma, 2020). Noise is unpleasant due to its intensity, exposure time, continuity and frequency. It is also one of the environmental pollution affecting the quality of life.

Sound or Noise pollution may occur due to the economic growth, urbanisation, anthropogenic activity etc. Globally it has become a severe issue and all nations are concerned about its health effects. This report presents the results of a baseline environmental noise survey carried out at different noise monitoring locations in the vicinity of the DHPC corridors of M/s. JSW Steel Ltd.

The Central Pollution Control Board (CPCB) has the responsibility to regulate and control sources of noise pollution with the objective of maintaining the ambient air quality standards (The principal rules were published in the Gazette of India, vide S.O. 123(E), dated 14.2.2000 and subsequently amended vide S.O. 1046(E), dated 22.11.2000, S.O. 1088(E), dated11.10.2002, S.O. 1569 (E), dated 19.09.2006 and S.O. 50 (E) dated 11.01.2010 under the Environment (Protection) Act, 1986).

According to the Central Pollution Control Board, the unit of noise is in decibel and represented as dB (A). Equivalent noise level (Leq) is the time weighted average 'A' of the level of sound in decibels on scale A and has been found related to human hearing. The dB(A) Leq, denotes the frequency weighing in the measurement of Noise and corresponds to frequency response characteristics of the human ear.

The noise data has been collected from November to December 2021 for post monsoon season. A standard method of recording the ambient noise continuously for 24 h has been followed for the study (Source: CPCB regulation and control rules, 2000) using Noise level meter (SV Corporation, Model S-12, Korea).

Noise level data were collected for every 1 second interval around specific locations of the DHPC corridors by recording the sound level pressure using the Noise level meter. Noise monitoring locations consists of different land uses such as agricultural land, forest area, settlements and sensitive zones mentioned in the ToRs.

Detailed standard 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 free-field microphone which met the accuracy of noise measurement as per IEC 804 (BS 6698) Grade I or Class-I.
- The station being 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.
- Microphone was placed 1.2 -1.5 m above the ground level in dry conditions with a wind speed of less 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 to10:00 Pm) and during 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}, 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.

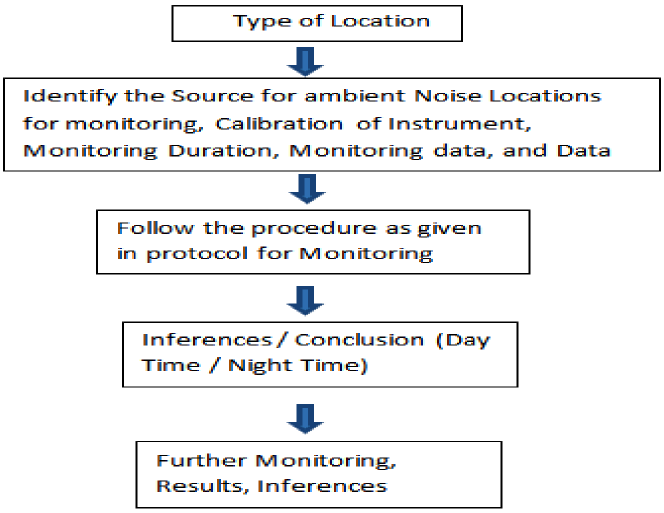
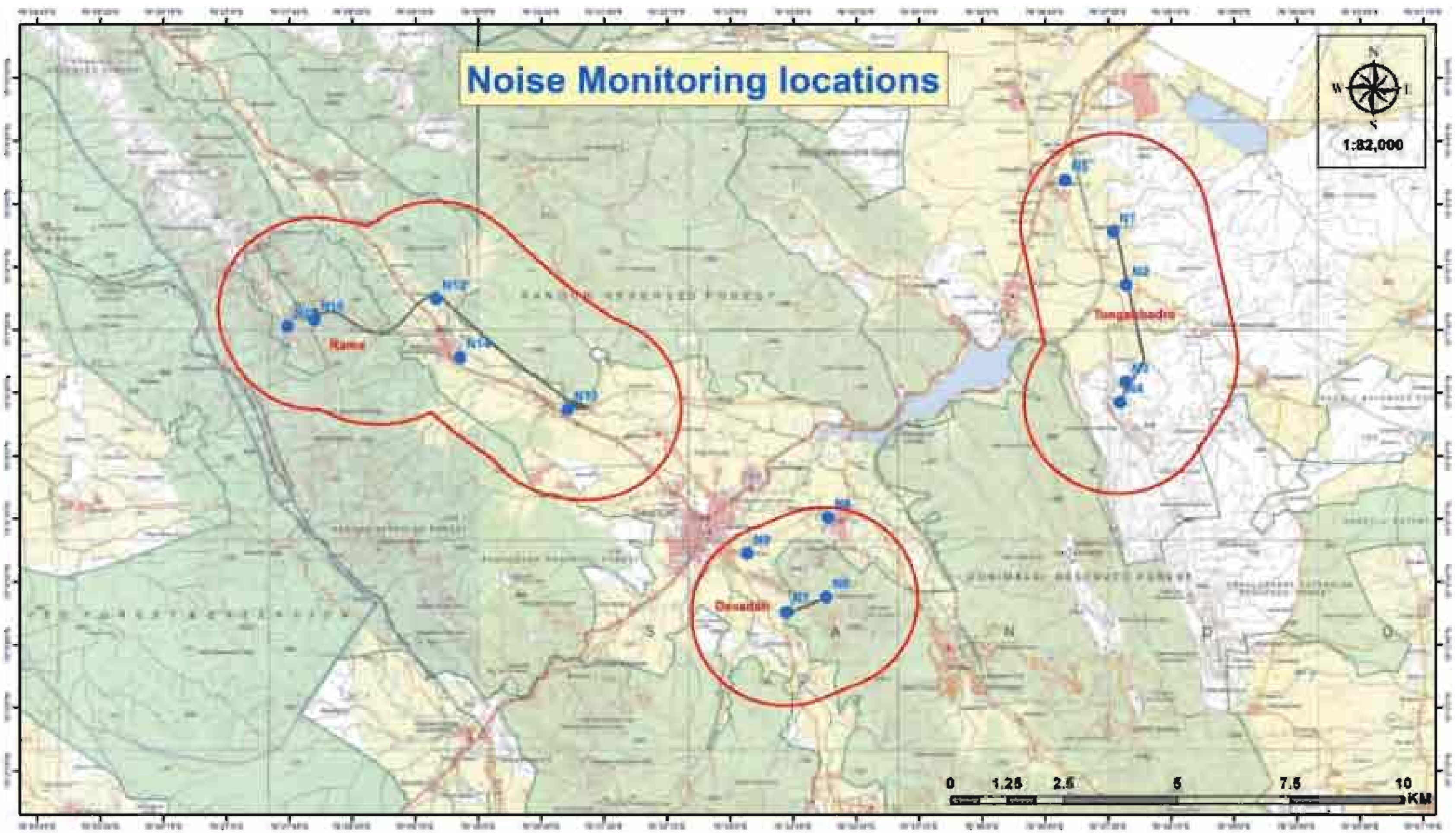


Figure 3.8 Schematic representation of noise monitoring methodology

Details of monitoring locations and the geographical coordinates of the same are given in Table 3.9. The monitored locations are represented on map and same is depicted in Figure 3.9.

Table 3.9 Details of noise monitoring locations

Sl No	Study Area	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



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	15.080568	76.553482	N14	15.119470	76.496444
N5	15.154709	76.616523	N10	15.126951	76.467404			

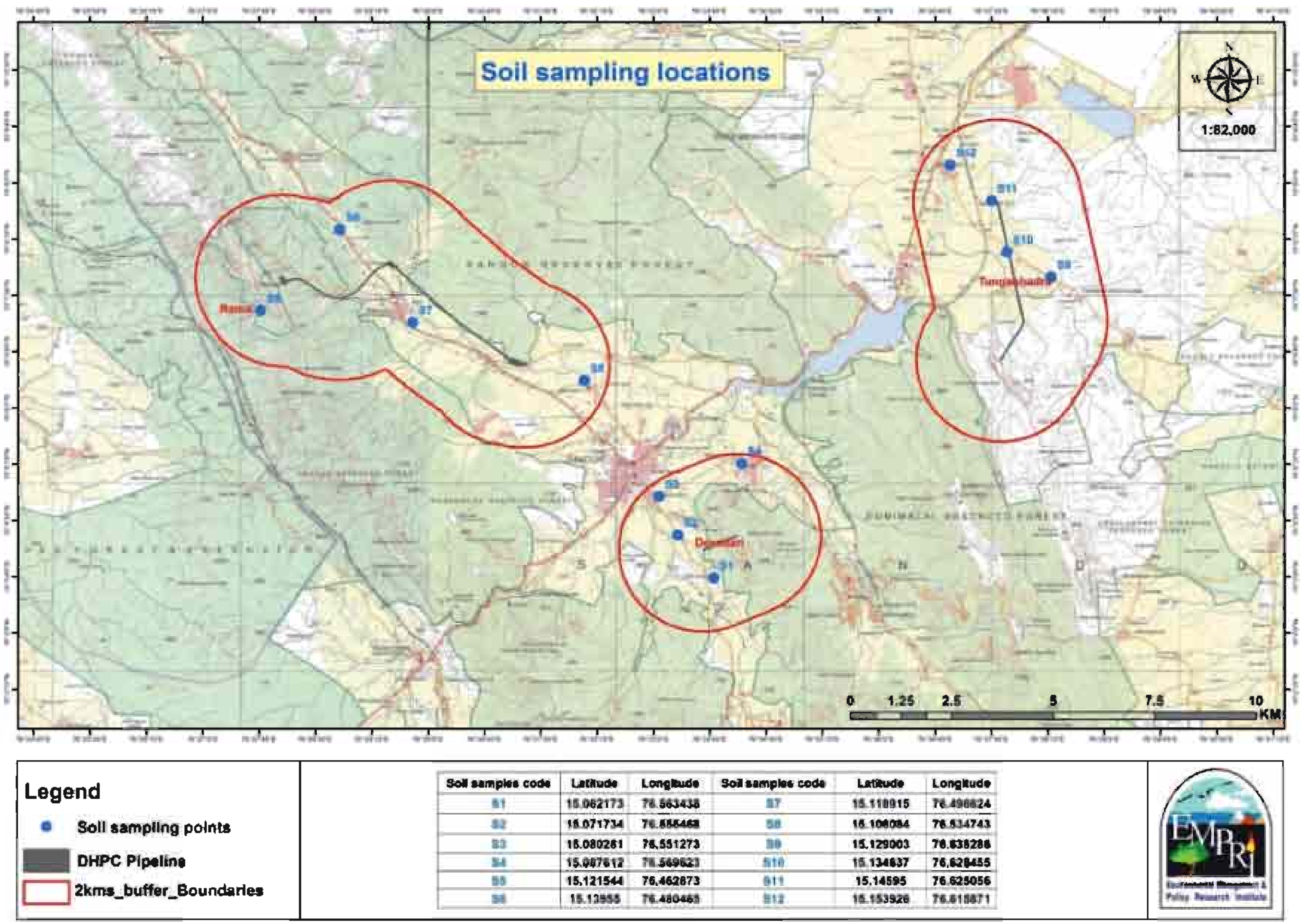
Figure 3.9 Map representing noise monitoring locations

3.4 ToR V - Soil Quality

Soil is a mixture of organic matter, minerals, gases, water and organisms. It is one of the most essential substrata for life on earth, also serving as a reservoir of water and nutrients. It is very important medium for water filtration and the breakdown of harmful compounds. It plays a major role in global nutrient cycle such as Carbon, Nitrogen and Oxygen cycle. Soil pollution refers to anything that causes contamination of soil and degrades the soil quality. It occurs when the pollutants reduce the quality of the soil and the soil become unsuitable for microorganisms and macro organisms living in the soil.

Soil sample collection varies based on 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 was done using soil auger.

The soil samples were collected from the identified sampling locations and analysed for the 2 physical and 18 chemical parameters, as mentioned in terms of references. Sampling locations map is given in Figure 3.10.



Soil samples code	Latitude	Longitude	Soil samples code	Latitude	Longitude
S1	15.062173	76.563436	S7	15.110915	76.496624
S2	15.071734	76.556468	S8	15.106084	76.534743
S3	15.080261	76.551273	S9	15.129003	76.638286
S4	15.087612	76.569623	S10	15.134637	76.628455
S5	15.121544	76.462873	S11	15.14595	76.625056
S6	15.13555	76.480465	S12	15.153926	76.615871

Figure 3.10 Map representing soil sampling locations

Soil auger and shovel were used in the field during sampling also Personal Protective Equipment's were worn to ensure safety. 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 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 3.11.

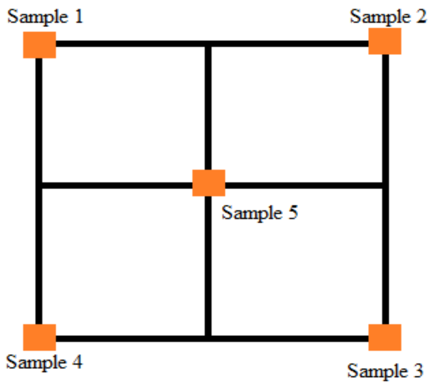


Figure 3.11 Pictorial representation of soil sampling methodology (Composite sampling)

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 same is given in Figure 3.12.
5. The collected samples were analysed. The parameters analysed and method followed is given in Table 3.12.

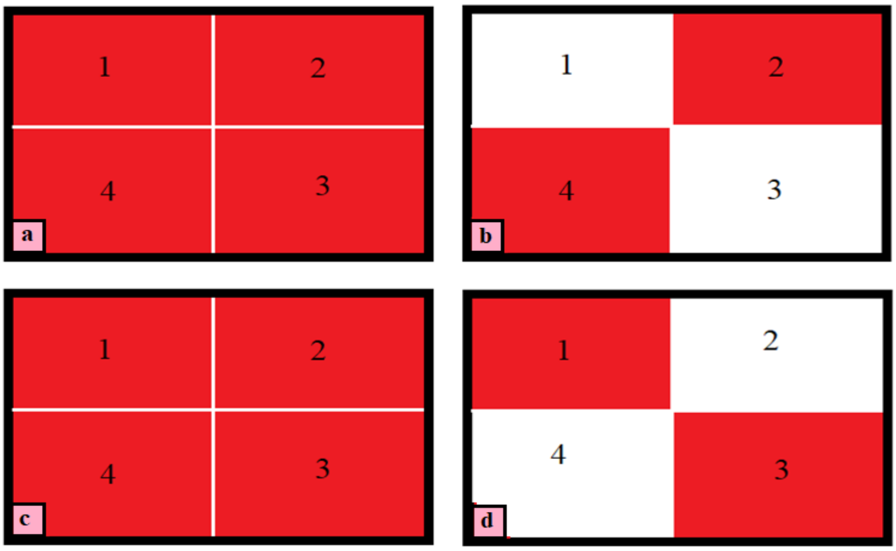


Figure 3.12 Pictorial representation of mixing soil samples

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

Sampling locations in Season I is given in Table 3.10 and sampling locations of Season II and III is given in Table 3.11 along with the habitat details.

Table 3.10 Details of soil sampling locations in Season I

Sl No	Study area	Location	GPS Coordinates		Habitat
			Latitude	Longitude	
1	Devadari DHPC	Lakshmipura	15.0780556 N	76.54527778 E	Settlement
2		Sennibasappa camp	15.08055556 N	76.55166667 E	Cultivation
3		Bhujanganagar	15.08722222 N	76.5630556 E	School
4		Narasapura	15.05277778 N	76.60000 E	Settlement
5	Rama DHPC	Ramgad Temple	15.09472222 N	76.57666667 E	Cultivation
6		Siddapura	15.15138889 N	76.47083333 E	Cultivation
7		Sushilnagar	15.12833333 N	76.49055556 E	Settlement
8	Tunga & Bhadra DHPC	Lingadahalli	15.11611111 N	76.6511111 E	Settlement
9		Bannihatti	15.155000 N	76.60388889 E	Cultivation
10		Taranagar	15.1333333 N	76.6100000 E	Settlement

Table 3.11 Details of soil sampling location in Season II & III

Sl No	Study area	Location	GPS Coordinates		Habitat
			Latitude	Longitude	
1	Devadari DHPC	Lakshmipura Extension	15.062338 N	76.563288 E	Settlement
2		Seenibasappa camp - School	15.071734 N	76.555388 E	School
3		ChikkaSandur	15.080190 N	76.550710 E	Cultivation
4		Bhujanganagar School	15.087612 N	76.569623 E	School
5	Rama DHPC	Ramgad - Tayamma Temple	15.121565 N	76.462931 E	Forest
6		Radhanagar	15.139157 N	76.480830 E	Cultivation
7		Sushilnagar School	15.118915 N	76.496624 E	School
8		Doulatpura	15.106084 N	76.534743 E	Cultivation
9	Tunga & Bhadra DHPC	Tunga & Bhadra Sponge Factory	15.129003 N	76.638286 E	Cultivation
10		Tunga & Bhadra Road Intersect	15.134637 N	76.628455 E	Cultivation
11		Bannihatti Transfer Point	15.145950 N	76.625056 E	Scrub forest
12		Bannihatti School	15.153926 N	76.615871 E	School

Table 3.12 Parameters analysed and analysis method for Soil parameters

Sl No	Parameters	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	Yet to be decided
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

3.5 ToR VI - Meteorology

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 and M/s JSW, Ballari is considered.

The methodology adopted for the present study is represented in the schematic diagram and the same is represented as Figure 6.1.

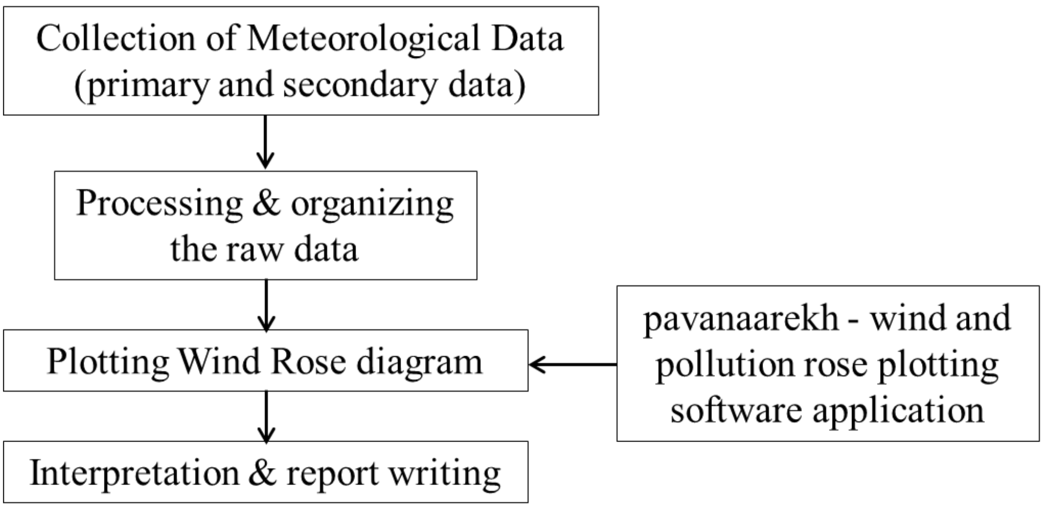


Figure 3.13 Schematic diagram of meteorological data analysis

The weather conditions related data *viz.* temperature, rainfall, relative humidity, wind speed, and wind direction are collected as primary and secondary data for the study area. Three meteorological stations were installed during different seasons. Due to this secondary data are used accordingly. The detail of meteorological stations installed by EMPRI is provided in Table 3.13.

Table 3.13 Details of meteorological stations installed by EMPRI

Sl No	Station name	Latitude	Longitude	Location
1	WS-JSW Rama Mines-Ramgad	15.124255˚N	76.467424˚E	Premises of M/s. JSW, Rama Iron ore mines, Ramgad village, Sandur Taluk, Ballari District
2	WS-Tunga Mines	15.10275936˚N	76.63253784˚E	Premises of M/s. JSW, Tunga Iron ore mines, Sandur Taluk, Ballari District
3	WS-Devadari Mines	15.1765785˚N	76.6233978˚E	Premises of M/s. JSW, Devadari Iron ore mines, Sandur Taluk, Ballari District

The secondary data are collected from M/s JSW, Ballari for all the three study areas in Season I. In Season II secondary data was collected for Devadari and Tunga & Bhadra from M/s JSW, Ballari. Three meteorological stations were installed and primary data was collected.

3.6 ToR VI – Socio-economic survey

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

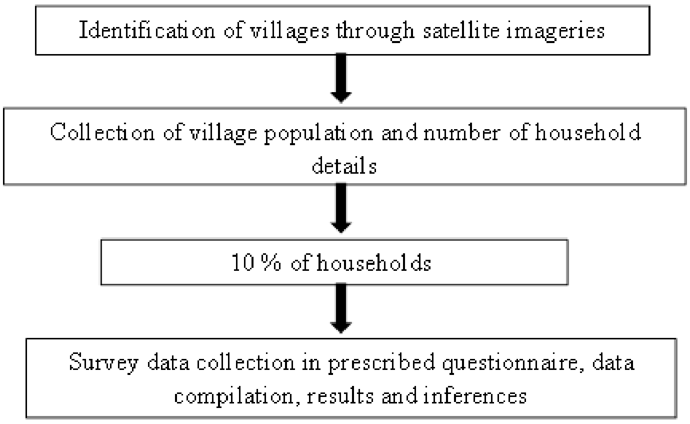


Figure 3.14 Schematic representation of socio-economic survey methodology

3.7 ToR VII - Land Use/Land Cover

In an urban environment, natural and human-induced environmental changes are of concern today because of deterioration of 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 great complexity of handling the multidisciplinary data set; we require new technologies like satellite remote sensing and Geographical Information Systems (GISs). These technologies provide data to study and monitor the dynamics of natural resources for environmental management (Robles and Luna, 2002).

In the present study remote sensing and GIS tools are used to analyse the LU/LC changes for the year 2012, 2018 and 2021. It is essential to understand the extent and trend of these changes both spatially and temporally to know about the changes in the regional environment. Different land use types reflect different ecological sensitivity. Based on the landscape ecology, human activities tend to make the outline of a landscape patch. Since the study area includes mining and industrial area, it is facing environmental pressure and most of the regions are affected by mining activities. The mining activities, impact the ecology and environment of ecosystem.

This chapter deals with the study of LU/LC change analysis for the year 2012, 2018 and 2021. Satellite imageries from National Remote Sensing Application Centre (NRSC) procured for the year 2012, 2018 and 2021and interpretation for the imageries are done to analyse the change detection. Arc GIS software is used for the interpretation and ERDAS Imagine software is used for image processing.

3.7.1 Study Area

The study area extends from longitudes 76°20'E - 76°55'E and latitude 15°00N - 15°15'0"N in Sandur taluk of Ballari district, Karnataka state. The Study area consists of 10km and 2km buffer zone on either side of the Down Hill Conveyer Belt (DHPC).

The GIS layers extracted from 2011 District Census published handbook with taluk-village maps shows that the 10km buffer zone encompasses parts of 87 villages (village boundaries) 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 2km and 10km buffer is shown in the Figure 3.15.

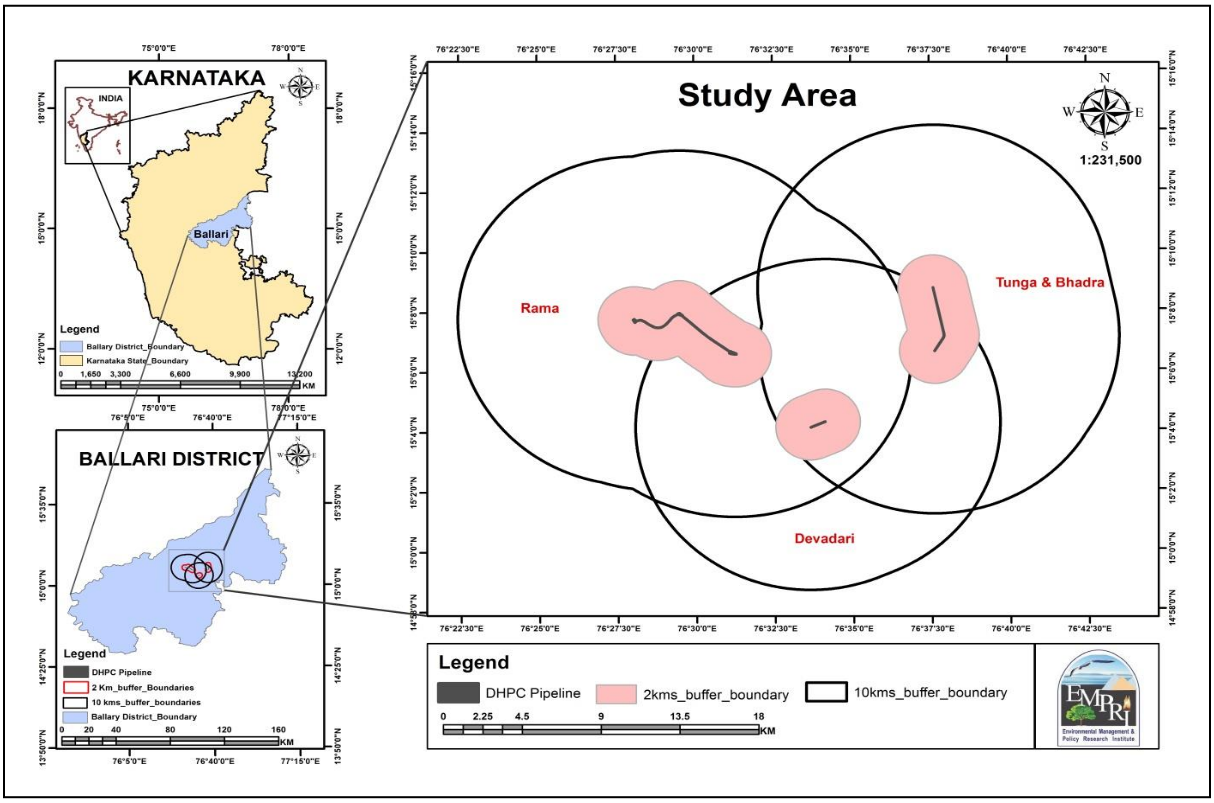


Figure 3.15 Study area map

3.7.2 Datasets

Land Use/Land Cover (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 was practiced to obtain the LU/LC patterns of the study area. In addition to the basic satellite imagery, other reference base data is necessary to achieve the objectives of image interpretation. This chapter provides the insight into the various data products used in this project.

3.7.3 Data products

For a comprehensive study of Land use/Land cover change detection studies, the following data products were used,

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

3.7.4 Toposheets

The Survey of India Toposheets have been taken as base maps for referring details of settlements, available administrative boundaries, reservoir FRL limits, etc. There are 6 toposheets of 1:50,000 scale for the study area. The toposheets also aid in geo-referencing the satellite imagery, identification of existing features such as forests, scrub regions, sheet rock areas and so on. The lists of toposheets used in this study are given in the Table 3.14.

Table 3.14 Details of toposheets used

Sl No	SOI Name
1	D43K05
2	D43E08
3	D43K09
4	D43E11
5	D43E12
6	D43E16

3.7.5 Satellite imagery

The Satellite imagery is the main data product which helps to delineate the LU/LC classification for the desired scale depending upon the resolution of the imagery. For the current study LISS IV satellite imageries of resolution 5.8m for the years 2012, 2018 and 2021 have been used to detect the decadal changes in LU/LC features in the study area.

3.7.5.1 Scale of LULC dataset

The scale of the data prepared is given by the formula

$$0.25\ mm \times scale = resolution\ of\ imagery$$

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

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

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

Satellite imagery map for 10 km and 2km buffer for Devadari, Rama and Tunga & Bhadra DHPC is given in Figure 3.16 to Figure 3.21.

Figure 3.16 Satellite imagery map-2021 for 10 Km Buffer – Devadari DHPC

Figure 3.17 Satellite imagery map-2021 for 10 Km Buffer – Rama DHPC

Figure 3.18 Satellite imagery map-2021 for 10 Km Buffer – Tunga & Bhadra DHPC

Figure 3.19 Satellite imagery map 2021 for 2km buffer – Devadari DHPC

Figure 3.20 Satellite imagery map 2021 for 2 km buffer – Rama DHPC

Figure 3.21 Satellite imagery map-2021 for 2 Km Buffer – Tunga & Bhadra DHPC

3.7.6 Google Earth

Google Earth maps are used for the reference to visualize and verify the location details with respect to the surrounding environment.

3.7.7 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.

3.7.8 Methodology

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 existing before and are existing presently will aid in assertion of changes which 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 an in-depth decadal changes occurred in Land-Use patterns. The process flow followed for the LU/LC change detection is shown in the Figure 3.22.

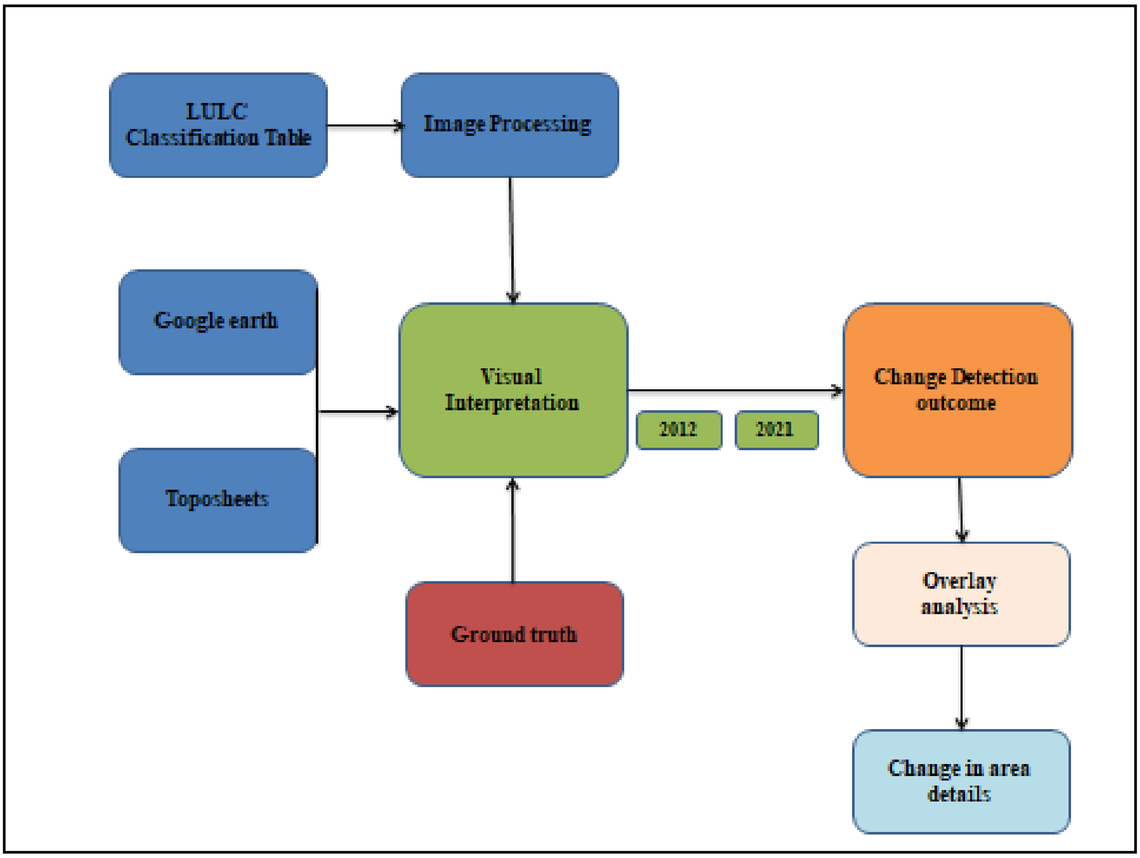


Figure 3.22 Flowchart for outline process steps followed in LU/LC change detection

4 Devadari DHPC

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

4.1 Results

4.1.1 ToR I – Inventorisation of water body

4.1.1.1 Season I

In the first season 10km area is considered for comprehensive study. Then secondary data is utilised and the results are given in Table 4.1.

Table 4.1 List of water bodies inventoried during season I

Sl No	Water body name	Distance (m)	Remarks	GPS Coordinates	
				Latitude	Longitude
1	Dharmapura Nalla	1050	Seasonal	15.065 N	76.551 E
2	Hulikunte Kere	900	Perennial	15.068 N	76.535 E
3	Narihalla	3610	Perennial	15.106 N	76.584 E

Three water bodies are present in the study area, out of which two are perennial and one is seasonal.

4.1.1.2 Season II and Season III

In second and third season only 1km area on either side of the DHPC was considered as per ToRs accorded and the results are given in Table 4.2.

Table 4.2 List of water bodies inventoried during season II and III

Sl No	Water body name	Distance (m)	Remarks	GPS Coordinates	
				Latitude	Longitude
1	Hulikunte Kere	900	Perennial	15.063 N	76.553 E

Only one water body was found in the study area i.e., Hulikunte kere which is a perennial water body spread over an area of 23.91 ha. Google imagery of the water body is given in Figure 4.1.

Figure 4.1 Google imagery of Hulikunte Kere

4.1.2 ToR II - Surface water and Groundwater

4.1.2.1 Season I (Surface water)

During first season only one surface water body i.e Narihalla was considered for water sampling since it is perennial. The results obtained are compared with designated water quality criteria and given in Table 4.3.

Table 4.3 Results of surface water quality during season I

Sl No	Parameters	Water Quality Criteria					Narihalla
		A	B	C	D	E	
1	pH	6.5 – 8.5				6 – 8.5	8.1
2	Odour	-	-	-	-	-	Odourless
3	Colour (Hazen)	-	10	300	300	-	2
4	Total Dissolved Solids (mg/L)	500	-	1500	-	2100	359
5	Chloride (mg/L)	250	-	600	-	600	87.5
6	Sulphate (mg/L)	400	-	400	-	1000	2.22
7	Fluoride (mg/L)	-	-	-	-	-	0.83
8	Boron (mg/L)	-	-	-	-	<2	BDL
9	Sodium (mg/L)	-	-	-	-	-	49
10	Iron (mg/L)	-	-	-	-	-	0.5798
11	Oil & Grease (mg/L)	-	-	-	-	-	BDL
12	Total Suspended Solid (mg/L)	-	-	-	-	-	3.8
13	Total Volatile Solid (mg/L)	-	-	-	-	-	0.0197
14	Chemical Oxygen Demand (mg/L)	-	-	-	-	-	8
15	Biochemical Oxygen Demand (mg/L)	≤2	≤3	≤3	-	-	BDL
16	Sulphide (mg/L)	-	-	-	-	-	BDL
17	Residual Sodium Carbonate (meL)	-	-	-	-	-	6.609
18	Phosphate (mg/L)	-	-	-	-	-	1.76
19	Total Coliform (MPN/100ml)	≤50	≤500	≤5000	-	-	920
20	Faecal Coliform (MPN/100ml)	-	-	-	-	-	920

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

In season I the water quality of Narihalla water body was found to be in Category 'C'.

4.1.2.2 Season II (Surface water)

During second season the study area considered was two kilometer radius on either side of the DHPC. Only one waterbody i.e Hulikunte kere was identified as potential water body for sampling. The results obtained are compared with designated water quality criteria and given in Table 4.4.

Table 4.4 Results of surface water quality during season II

Sl No	Particular	Units	Water Quality Criteria					Hulikunte kere
			A	B	C	D	E	
1	pH at 25℃		6.5 – 8.5				6 – 8.5	7.3
2	Odour	--	-	-	-	-	-	Odourless
3	Colour	Hazen	-	10	300	300	-	10
4	Total Dissolved Solids	mg/L	500	-	1500	-	2100	223
5	Chlorides	mg/L	250	-	600	-	600	30.27
6	Sulphate	mg/L	400	-	400	-	1000	25.18
7	Fluoride	mg/L	-	-	-	-	-	BDL
8	Boron	mg/L	-	-	-	-	<2	0.1626
9	Sodium	mg/L	-	-	-	-	-	31
10	Iron	mg/L	-	-	-	-	-	5.3274
11	Oil & Grease	mg/L	-	-	-	-	-	BDL
12	Total Suspended Solids	mg/L	-	-	-	-	-	83.6
13	Total Volatile Solids	mg/L	-	-	-	-	-	204.4
14	COD	mg/L	-	-	-	-	-	16
15	BOD (3 days @ 27℃)	mg/L	≤2	≤3	≤3	-	-	BDL
16	Sulphide	mg/L	-	-	-	-	-	0.001
17	Residual Sodium Carbonate	mg/L	-	-	-	-	-	BDL
18	Phosphate	mg/L	-	-	-	-	-	0.058
19	Total coliform	MPN /100 mL	≤50	≤500	≤5000	-	-	920
20	Faecal coliform		-	-	-	-	-	920

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

In season II the water quality of Hulikunte kere was found to be Category C.

4.1.2.3 Season III (Surface water)

During third season the study area considered was two kilometer radius on either side of the DHPC. Only Hulikunte kere was identified as potential water body for sampling. The results obtained are compared with designated water quality criteria and given in Table 4.5.

Table 4.5 Results of surface water quality during season III

Sl No	Particular	Units	Water Quality Criteria					Hulikunte kere
			A	B	C	D	E	
1	pH at 25℃		6.5 – 8.5				6 – 8.5	6.8
2	Odour	--	-	-	-	-	-	Odourless
3	Colour	Hazen	-	10	300	300	-	1
4	Total Dissolved Solids	mg/L	500	-	1500	-	2100	263
5	Chlorides	mg/L	250	-	600	-	600	39.9
6	Sulphate	mg/L	400	-	400	-	1000	24.1
7	Fluoride	mg/L	-	-	-	-	-	0.4
8	Boron	mg/L	-	-	-	-	-	0.06
9	Sodium	mg/L	-	-	-	-	-	78
10	Iron	mg/L	-	-	-	-	-	0.81
11	Oil & Grease	mg/L	-	-	-	-	-	0.6
12	Total Suspended Solids	mg/L	-	-	-	-	-	15.4
13	Total Volatile Solids	mg/L	-	-	-	-	-	25
14	COD	mg/L	-	-	-	-	-	24.2
15	BOD (3 days @ 27℃)	mg/L	≤2	≤3	≤3	-	-	3
16	Sulphide	mg/L	-	-	-	-	-	BDL
17	Residual Sodium Carbonate	mg/L	-	-	-	-	-	BDL
18	Phosphate	mg/L	-	-	-	-	-	BDL
19	Total coliform	MPN/ 100mL	≤50	≤500	≤5000	-	-	33
20	Faecal coliform	MPN/ 100mL	-	-	-	-	-	11

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

In season III the water quality of Hulikunte kere was found to be in Category B.

4.1.2.4 Discussion – seasonal variation of surface water

The water quality of Narihalla was found to be falling under Category C. Since water sampling location has been changed from first season to second & third, comparison can't be projected for Season I with Season II and III. In this context the comparison was made for Hulikunte water body alone which was sampled in the season II and III. It was observed that the quality of water body has improved from Category C to Category B in Season III.

However, the water bodies are not directly influenced by the construction of the DHPCs.

4.1.2.5 Season I (Groundwater)

During first season, four groundwater sampling locations were identified and samples were collected and analysed. The results obtained are compared with Drinking water quality standards and given in Table 4.6.

Table 4.6 Results of groundwater quality for season I

Sl No	Parameters	Units	Std. IS 10500:2012*		Lakshmipura	Seenibasappa camp school	Bhujanganagar school	Narasapura
			AL*	PL*				
1	pH at 25°C	-	6.5 – 8.5	NR	7.3	7.5	7.5	8
2	Colour	Hazen	5	15	1	1	1	1
3	Odour		Agreeable		Agreeable			
4	Total Dissolved Solids	mg/L	500	2000	522	812	969	1516
5	Turbidity	NTU	1	5	0.3	0.8	0.6	0.5
6	Chloride	mg/L	250	1000	77.4	104.9	229.9	462.3
7	Total hardness	mg/L	200	600	360	585	585	905
8	Calcium as Ca	mg/L	75	200	90.1	128.2	146.2	188.3
9	Magnesium as Mg	mg/L	30	100	32.8	64.3	53.4	105.7
10	Alkalinity as $CaCO_3$	mg/L	200	600	320	470	370	455
11	Sulphate as SO_4	mg/L	200	400	5.33	22.2	57.8	103.6
12	Fluoride as F	mg/L	1	1.5	1.03	BDL	BDL	0.56
13	Boron as B	mg/L	0.5	1	BDL	BDL	BDL	BDL
14	Sodium as Na	mg/L	--		51	62	70	82
15	Potassium as K	mg/L	--		0.4	0.4	1.6	0.4
16	Total Chromium	mg/L	0.05	NR	0.017	0.010	0.028	BDL
17	Copper(Cu)	mg/L	0.05	1.5	BDL	BDL	BDL	BDL
18	Iron(Fe)	mg/L	0.3	NR	0.3892	0.245	0.2224	0.2959
19	Lead (Pb)	mg/L	0.01	NR	BDL	BDL	BDL	BDL
20	Manganese (Mn)	mg/L	0.1	0.3	BDL	BDL	BDL	BDL
21	Zinc (Zn)	mg/L	5	15	0.103	BDL	1.5373	0.058
22	Cadmium (Cd)	mg/L	0.003	NR	0.0255	0.037	0.0421	0.0455
23	Nitrate	mg/L	45	NR	23.12	16.12	20.32	mg/L
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	0.496	BDL	BDL	0.006

Sl No	Parameters	Units	Std. IS 10500:2012*		Lakshmipura	Seenibasappa camp school	Bhujanganagar school	Narasapura
			AL*	PL*				
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	BDL	BDL	0.002	BDL
28	Total Coliform	MPN/ 100mL	Nil	Nil	Nil	Nil	Nil	Nil
*AL- Acceptance Limit, PL- Permissible Limit, OL- Odourless, BDL- Below Detection Limit, NR- No Relaxation, S- Season								

Graphical representation of the Total hardness, Calcium and Magnesium is given in Figure 4.2 to show the balanced ration (TH ≥ Ca + Mg).

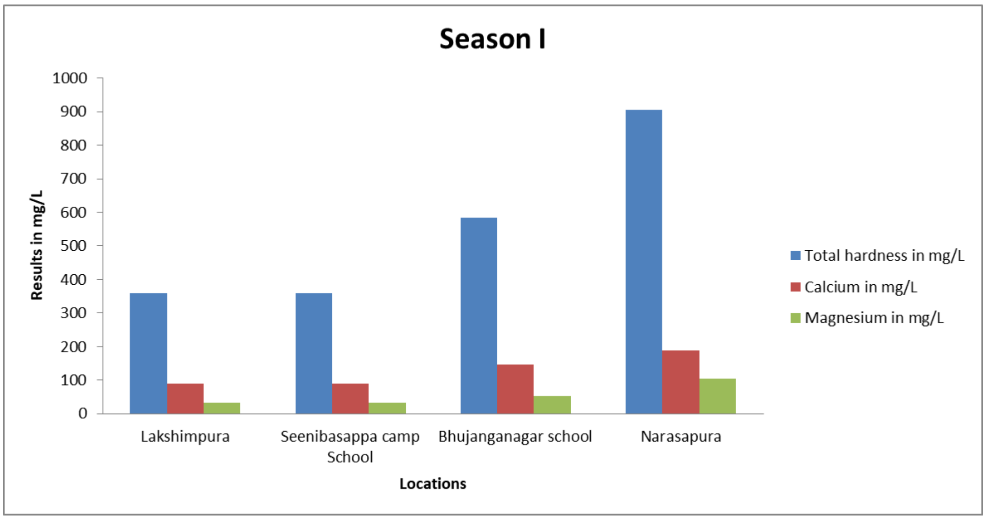


Figure 4.2 Graphical representation of TH, Ca and Mg for season I

Total hardness with Iron, Aluminium and Cadmium concentration have exceeded the permissible limits. The Water Quality Index of the samples were calculated and graphically represented as Figure 4.3. **The quality of the water ranged between Excellent – A to Good – B.**

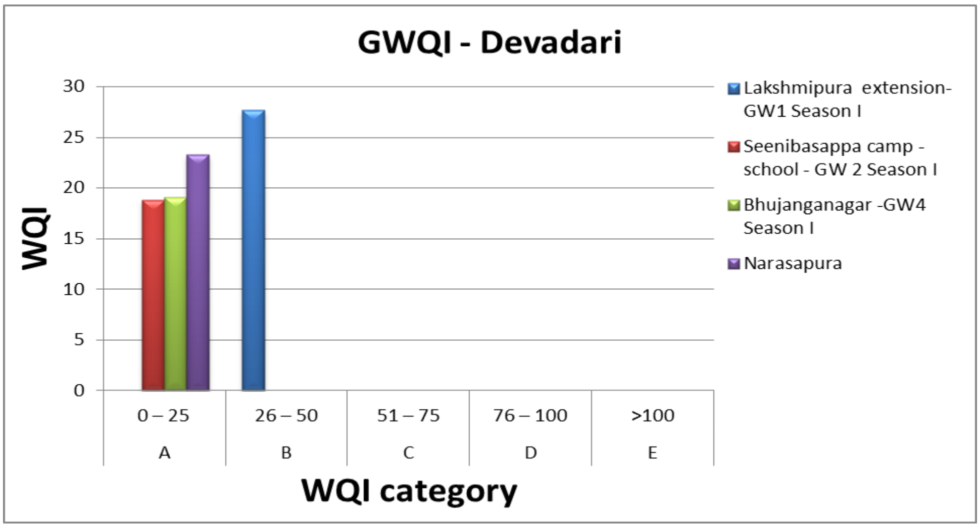


Figure 4.3 Graphical representation of GWQI for season I

4.1.2.6 Season II

During second season, four groundwater sampling locations were identified and samples were collected and analysed. The results obtained have been compared with Drinking water quality standards and are given in Table 4.7.

Table 4.7 Results of groundwater quality in season II

Sl No	Particular	Units	Std. IS 10500:2012* AL*	PL*	Lakshmipura Extension	Seenibasappa camp school	ChikkaSandur	Bhujanganagar School
1	pH	--	6.5 - 8.5	NR	6.4	6.6	6.4	6.4
2	Odour		Agreeable		Odourless			
3	Colour	Hazen	5	15	1	1		
4	Total Dissolved Solids	mg/L	500	2000	1035.2	789.2	1346	1203.6
5	Chlorides	mg/L	250	1000	178.6	118.1	324.8	339.8
6	Sulphate	mg/L	200	400	81.73	50.56	88.57	88.18
7	Fluoride	mg/L	1	1.5	BDL	BDL	BDL	BDL
8	Boron	mg/L	0.5	1	0.48	0.38	0.41	0.44
9	Calcium	mg/L	75	200	164.3	168.3	172.3	188.3
10	Sodium	mg/L	--		111	93	106	95
11	Iron	mg/L	0.3	NR	0.22	0.22	0.32	0.3
12	Turbidity	mg/L	1	5	0.03	0.04	0.26	0.21
13	Total Hardness	mg/L	200	600	590	530	690	770
14	Magnesium	mg/L	30	100	43.7	26.7	63.1	72.9
15	Nitrate	mg/L	45	NR	0.4	0.04	0.2	0.5
16	Total Alkalinity	mg/L	200	600	478	412	472	404
17	Potassium	mg/L	--		2	BDL	BDL	1
18	Copper	mg/L	0.05	1.5	BDL	BDL	BDL	BDL
19	Manganese	mg/L	0.1	0.3	BDL	BDL	BDL	BDL
20	Zinc	mg/L	5	15	BDL	BDL	BDL	BDL
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL	BDL
22	Lead	mg/L	0.01	NR	0.06	0.08	0.07	0.05
23	Total Chromium	mg/L	0.05	NR	0.1	BDL	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	4.18	0.469	0.377	0.387
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	0.02	0.001	0.011	0.006
28	Total Coliform	MPN/ 100mL	Nil		48	350	47	<1.8

*AL- Acceptance Limit, PL- Permissible Limit, OL- Odourless, BDL- Below Detection Limit, NR- No Relaxation, S- Season

Graphical representation of the Total hardness, Calcium and Magnesium is given in Figure 4.3 to show the balanced ration (TH $\geq$ Ca + Mg).

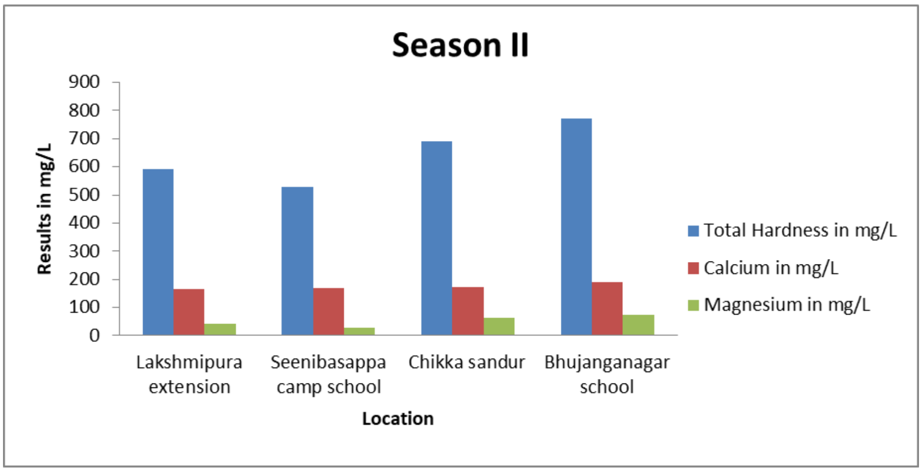


Figure 4.4 Graphical representation of TH, Ca and Ma in season II

The Water Quality Index of the samples were calculated and graphically represented as in Figure 4.5. The GWQI during season II ranged between good - B to poor – C. This is primarily because of excess hardness and alkalinity with Iron, Aluminium, Lead and Total Chromium concentration exceeding the permissible limits. Naturally the study area has rich Iron content in it.

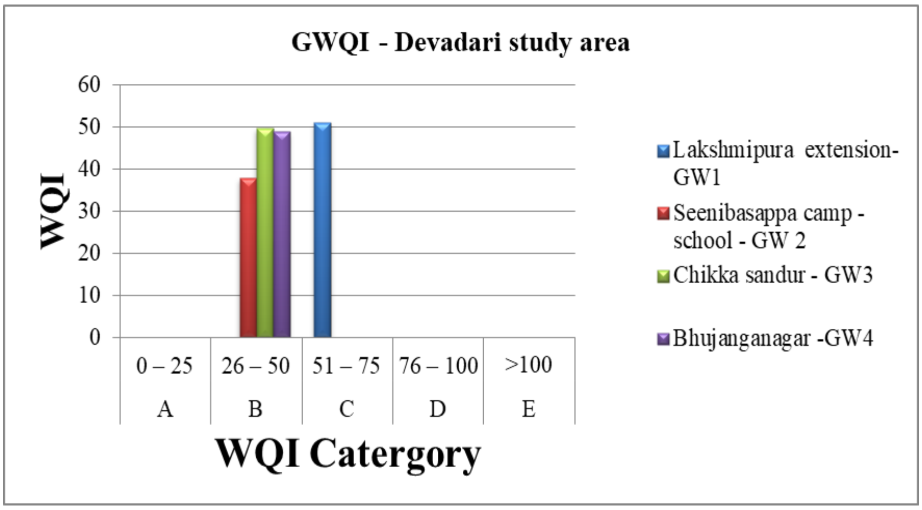


Figure 4.5 Graphical representation of Groundwater quality index for season II

4.1.2.7 Season III

During third season, four groundwater sampling locations were identified and samples were collected and analysed. The results obtained are compared with Drinking water quality standards and are given in Table 4.8.

Table 4.8 Results of groundwater quality in season III

Sl No	Particular	Units	Std. IS 10500:2012*		Lakshmipura Extension	Seenibasappa camp school	Chikka Sandur	Bhujanganagar School
			AL*	PL*				
1	pH	--	6.5 - 8.5	NR	7.3	7.6	7.2	7.2
2	Odour		Agreeable		Odourless			
3	Colour	Hazen	5	15	1	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	878.8	911.6	1803.2	1830
5	Chlorides	mg/L	250	1000	109.9	119.9	349.8	414.8
6	Sulphate	mg/L	200	400	43.8	44.2	88.3	95.5
7	Fluoride	mg/L	1	1.5	0.57	0.8	0.36	0.5
8	Boron	mg/L	0.5	1	0.15	0.15	0.21	0.18
9	Calcium	mg/L	75	200	204.2	227.8	310.3	361.4
10	Sodium	mg/L	--		101.5	103	275	409
11	Iron	mg/L	0.3	NR	0.16	0.16	0.09	0.15
12	Turbidity	mg/L	1	5	0.18	3.8	1.6	0.35
13	Total Hardness	mg/L	200	600	648.9	638.6	1246.3	1328.7
14	Magnesium	mg/L	30	100	33.8	17.1	114.7	103.8
15	Nitrate	mg/L	45	NR	9.5	9.2	10.2	10.2
16	Total Alkalinity	mg/L	200	600	368	288	244	204
17	Potassium	mg/L	--		10.4	2.8	3.6	7.2
18	Copper	mg/L	0.05	1.5	0.05	0.06	BDL	0.05
19	Manganese	mg/L	0.1	0.3	BDL	0.65	BDL	BDL
20	Zinc	mg/L	5	15	BDL	0.59	BDL	0.06
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL	BDL
22	Lead	mg/L	0.01	NR	0.89	BDL	0.06	BDL
23	Total Chromium	mg/L	0.05	NR	BDL	BDL	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	0.006	0.005	BDL
25	Aluminium	mg/L	0.003	NR	0.294	0.649	0.389	0.394
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL	BDL
27	T.otal Arsenic	mg/L	0.01	0.05	0.002	BDL	0.003	0.004
28	Total Coliform	MPN/ 100mL	Nil		220	<1.8	13	<1.8

*AL- Acceptance Limit, PL- Permissible Limit, OL- Odourless, BDL- Below Detection Limit, NR- No Relaxation, S- Season

Graphical representation of the Total hardness, Calcium and Magnesium is given in Figure 4.4 to show the balanced ration (TH ≥ Ca + Mg).

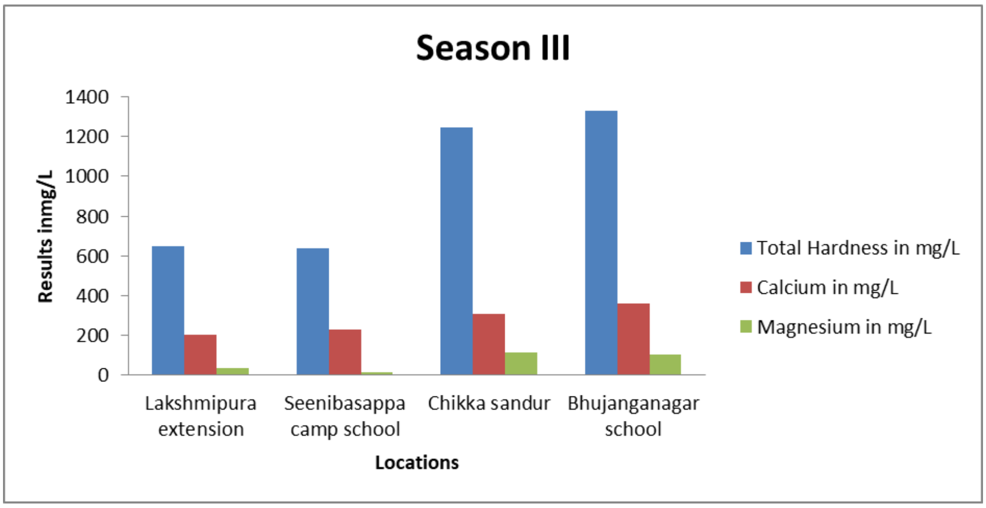


Figure 4.6 Graphical representation of TH, Ca and Ma in season III

Total hardness along with Aluminium, Manganese, Lead and Mercury concentration exceeded the permissible limit. The GWQI during season III ranged between excellent – A grade to good – B grade. However values of seenibasappa camp were too high i.e., unsuitable – E grade, graphical representation of the same is given in Figure 4.5.

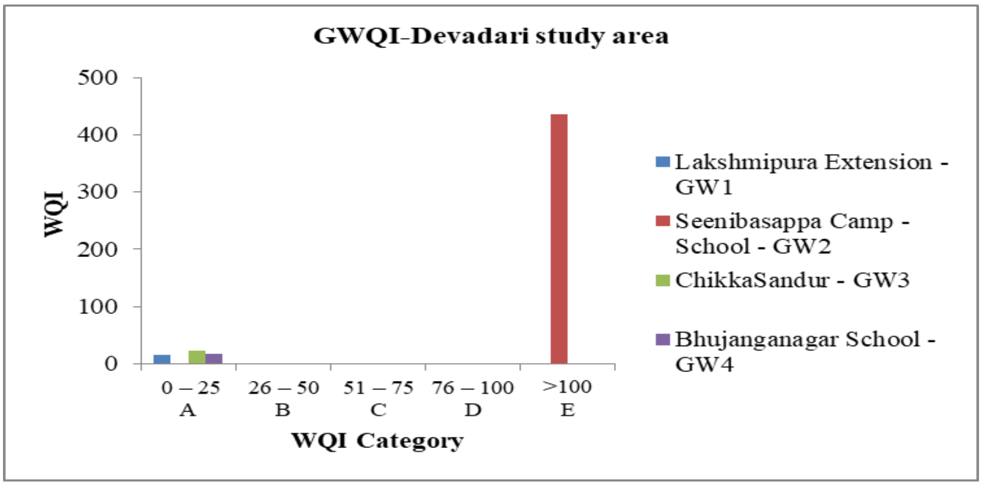


Figure 4.7 Graphical representation of Groundwater quality index for season III

4.1.2.8 Discussions – seasonal variations in groundwater quality

In all the seasons, hardness value was of groundwater observed to be higher than the standard. Although hardness does not cause any health impact on humans it results in scale formation. Fluoride was found to be below detection level in all the samples and seasons. Heavy metals like Iron, Aluminium, Manganese, Lead, Cadmium, Total Chromium and Mercury concentration exceeded the permissible limit. The ground water quality index ranged from A to B, B to C and A to E in seasons I, II and III respectively. However, in all locations water quality index was either A – excellent or B - good except in Lakshmipura extension where it was C – poor, during season II and Seenibasappa camp it was E – unsuitable, during season III.

Sl No	Location name	Sample code	WQI	Grade
1	Lakshmipura Extension	GW 1	16.35	A
2	Seenibasappa Camp - School	GW 2	435.33	E
3	ChikkaSandur	GW 3	22.29	A
4	Bhujanganagar School	GW 4	17.89	A

4.1.3 ToR III – Ambient Air

4.1.3.1 Season I

During first season, air monitoring was conducted in only one location i.e., Bhujanganagar school, the results are given in Table 4.9. It is not compared to any standards since 24h monitoring was not conducted due to rain. $PM_{2.5}$ was not monitored.

Table 4.9 Results of ambient air in season I

Location	GPS coordinates		Units	PM_{10}	SO_2	NO_2
	Latitude	Longitude				
NAAQM Stds	**--**	**--**	**µg/m³**	**100**	**80**	**80**
Bhujanganagar School	15º5’16.89”N	76º34’10.11”E	µg/m³	131.3	BDL	BDL
	15º5’16.89”N	76º34’10.11”E	µg/m³	57	BDL	BDL
	15º5’16.89”N	76º34’10.11”E	µg/m³	331.8	BDL	BDL
	15º5’16.89”N	76º34’10.11”E	µg/m³	300.5	BDL	BDL

4.1.3.2 Season II

During second season air monitoring was conducted in 4 locations. The results are given in Table 4.10, the results obtained were compared with National Ambient Air Quality Standards.

Table 4.10 Results of ambient air in season II

Sl No	Locations	Units	PM_{10}	$PM_{2.5}$	SO_2	NO_2
	NAAQ Stds	**$\mu g/m^3$**	**100**	**60**	**80**	**80**
1	Devadari Hopper Point	$\mu g/m^3$	180.04	52.11	101.95	2.04
2	Devadari Transfer Point	$\mu g/m^3$	223.63	38.32	132.46	21.89
3	Bhujanganagar School	$\mu g/m^3$	254.8	69.04	19.56	3.18
4	Lakshmipura Village	$\mu g/m^3$	106.75	50.98	994.2	19.62

Graphical representation for season II is given in Figure 4.8, 4.9 and 4.10 for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 respectively.

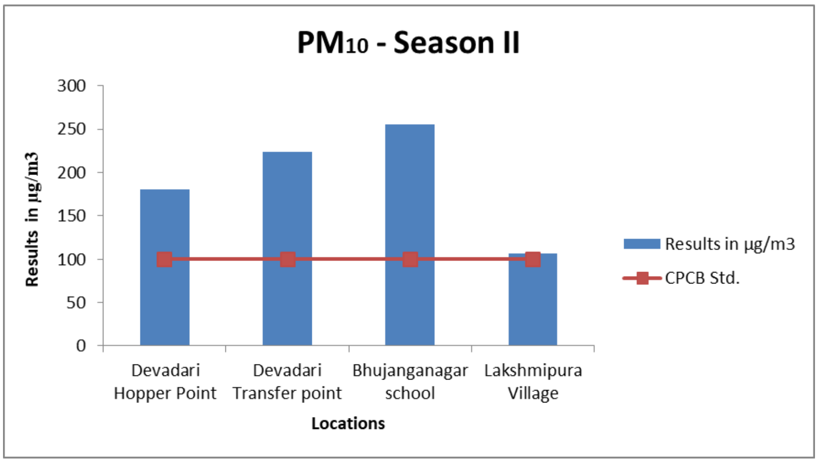


Figure 4.8 Graphical representation of PM_{10} for season II

During season II, Particulate Matter -10 was beyond standard in all the locations which is due to the vehicular movement, the dust agitated due to the vehicular movements rise Particulate Matter.

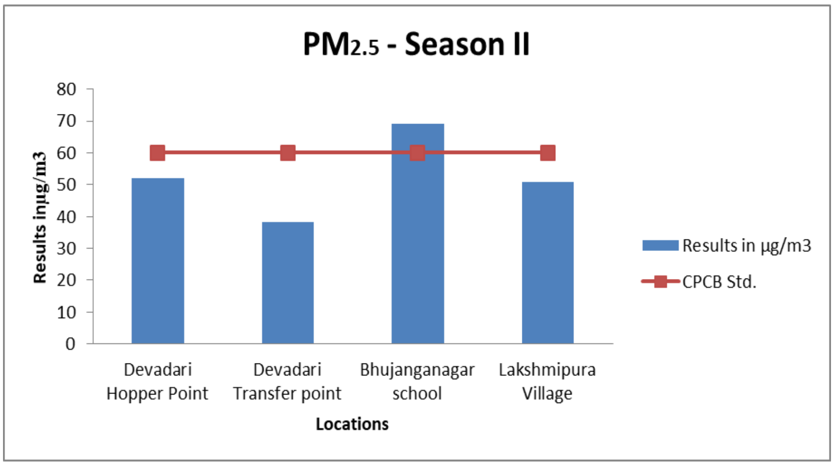


Figure 4.9 Graphical representation of $PM_{2.5}$ for season II

During season II, Particulate Matter -2.5 was beyond the limit in Bhujanganagar School. This might be due to the dust that tends to rise from the school playground.

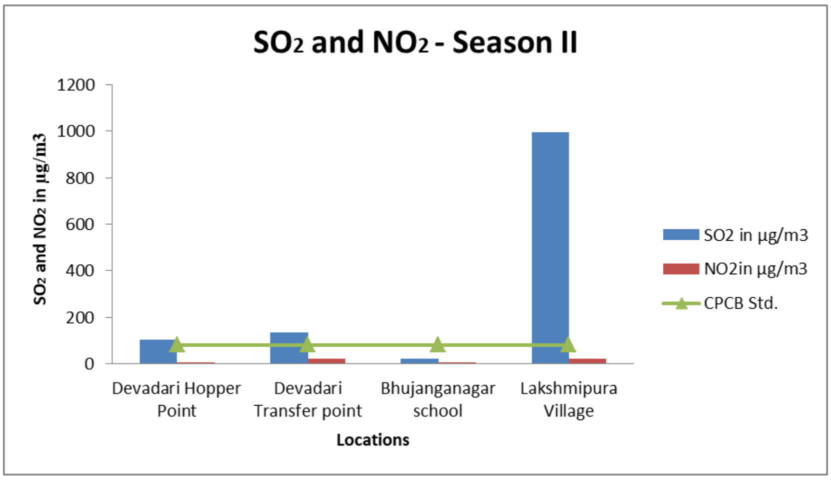


Figure 4.10 Graphical representation of SO_2 and NO_2 for season II

During season II, SO_2 was beyond limit in all the locations except Bhujanganagar School. This is because of the vehicular emissions due to movement of more lorries.

Table 4.11 AQI category as per CPCB

Sl No	Air Quality Index	Category
1	0 - 50	Good
2	51 - 100	Satisfactory
3	101 - 200	Moderate
4	201 - 300	Poor
5	301 - 400	Very poor
6	>401	Severe

Table 4.12 AQI for season II

Sl No	Location Name	Air Quality Index	Category
1	Devadari Hopper Point	153	Moderate
2	Devadari Transfer Point	182	Moderate
3	Bhujanganagar School	205	Poor
4	Lakshmipura Village	324	Very poor

During second season, Air Quality Indices (AQI) of four locations were calculated using Central Pollution Control Board (CPCB) AQI calculator. Results revealed that in season II, AQI was moderate to very poor in the study area.

4.1.3.3 Season III

During third season, air monitoring was conducted in 4 locations. The results are given in Table 4.13 obtained results were compared with National Ambient Air Quality Standards.

Table 4.11 Results of ambient air in season III

Sl No	Locations	Units	PM_{10}	$PM_{2.5}$	SO_2	NO_2
	NAAQ Stds	**$\mu g/m^3$**	**100**	**60**	**80**	**80**
1	Devadari Hopper Point	$\mu g/m^3$	369.57	66.17	1.06	10.19
2	Devadari Transfer Point	$\mu g/m^3$	307.73	74.14	1.82	19.60
3	Bhujanganagar School	$\mu g/m^3$	673.71	121.45	1.96	28.32
4	Lakshmipura Village	$\mu g/m^3$	411.31	93.64	4.17	22.21

Graphical representation for season III is given in Figure 4.11, 4.12, 4.13 for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 respectively.

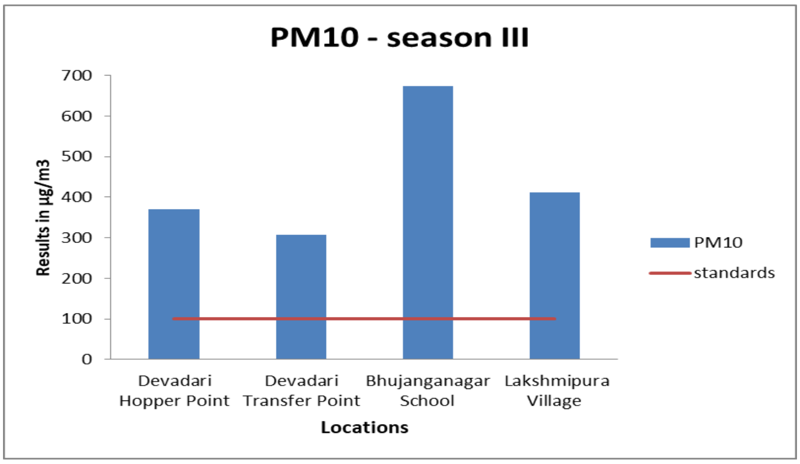


Figure 4.11 Graphical representation of PM_{10} for season III

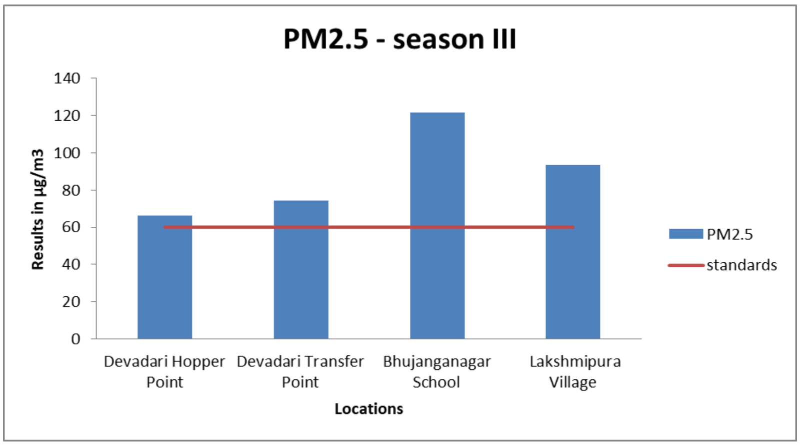


Figure 4.12 Graphical representation of $PM_{2.5}$ for season III

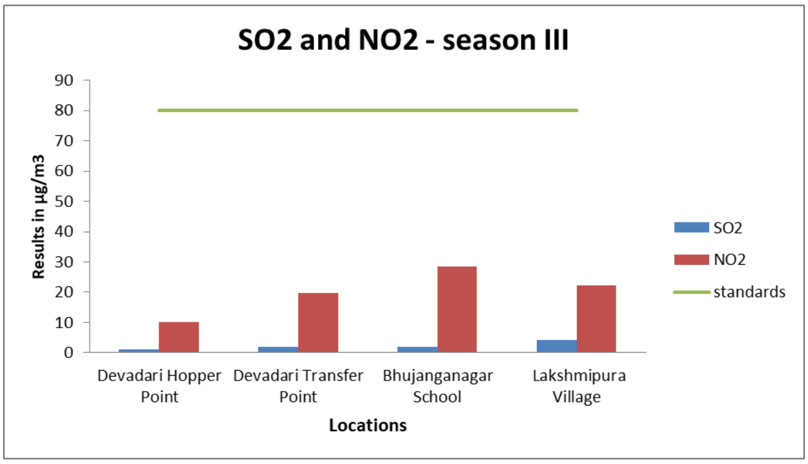


Figure 4.13 Graphical representation of SO_2 and NO_2 for season III

Values of PM_{10} and $PM_{2.5}$ have exceeded in all the locations during Season III. The highest value was observed in Bhujanganagar school. The probable reason would be the dust from play grounds. SO_2 and NO_2 values were well within the standards in Season III.

Table 4.14 AQI for season III

Sl No	Location Name	Air Quality Index	Category
1	Devadari Hopper Point	324	Very Poor
2	Devadari Transfer Point	258	Poor
3	Bhujanganagar School	705	Severe
4	Lakshmipura Village	377	Very Poor

During third season, Air Quality Indices (AQI) of five locations was calculated using Central Pollution Control Board (CPCB) AQI calculator. Results revealed that in season II, AQI varied from poor to severe category in the study area.

4.1.3.4 Seasonal variation – Air

During first season, monitoring was not conducted for 24 h due to rain. However, in season II and III, 24 h monitoring was conducted. The results during season II, revealed that Particulate Matter-10 was beyond standards in all the locations. Particulate Matter-2.5 was beyond the limit only in Bhujanganagar School. SO_2 was beyond limit in all the locations except Bhujanganagar School. NO_2 was well within limits. During season III, the values of PM_{10} and $PM_{2.5}$ exceeded in all the locations but SO_2 and NO_2 values were well within the standards.

Overall it is seen that Particulate matter values are too high, irrespective of locations and seasons. This might be due to movement of lorries carrying ores. The area is also found to have muddy roads which cause the dust particles to rise up easily with wind and also due to heavy vehicular movement.

4.1.4 ToR IV – Noise monitoring

4.1.4.1 Season I

During first season, noise monitoring was conducted only in one location i.e., Ranjithpura. The results are given in Table 4.15 and are not compared to any standards since 24h monitoring was not conducted due to rain.

Table 4.12 Results of noise monitoring in season I

Time	Results in dB(A)
6 Am	46.38
7 Am	45.75
8 Am	43.25
10 Am	42.06
11 Am	39.36
12 Pm	36.77
1 Pm	44.30
2 Pm	48.17
3 Pm	53.48
4 Pm	49.93

4.1.4.2 Season II

During second season, noise monitoring was conducted in four locations. The results are given in Table 4.16.

Table 4.16 Results of noise monitoring for season II

Sl No	Locations	Zone	CPCB Standards in dB(A)		Results in dB(A)	
			Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)
1	Devadari Hopper Point	Silence Zone	50	40	28.42	26.79
2	Devadari Transfer Point	Silence Zone	50	40	36.34	27.17
3	Bhujanganagar School	Silence Zone	50	40	34.72	34.53
4	Lakshmipura Village	Residential Area	55	45	33.31	33.13

Graphical representation of noise results for second season is given in Figure 4.14.

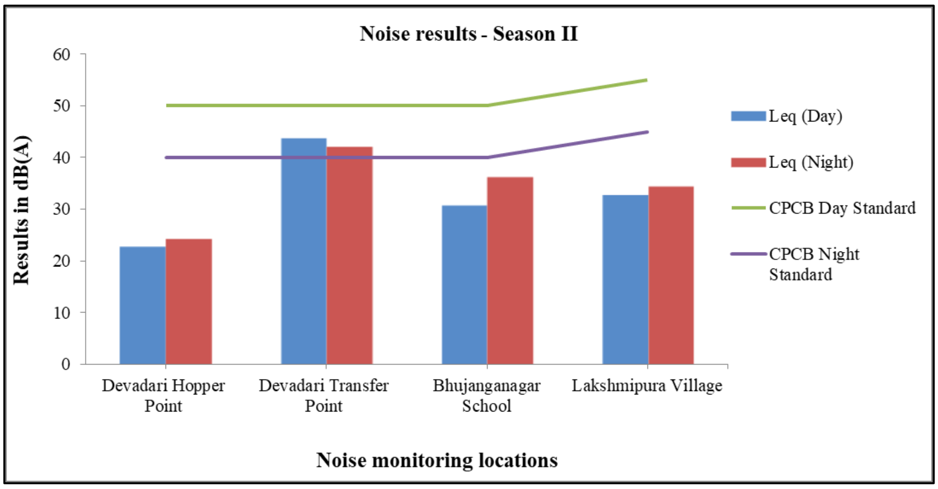


Figure 4.14 Graphical representation of noise results – season II

4.1.4.3 Season III

During third season, noise monitoring was conducted in four locations. The results are given in Table 4.17.

Table 4.13 Results of noise monitoring for season III

Sl No	Locations	Zone	CPCB Standards in dB(A)		Results in dB(A)	
			Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)
1	Devadari Hopper Point	Silence Zone	50	40	22.88	24.40
2	Devadari Transfer Point	Silence Zone	50	40	43.65	42.05
3	Bhujanganagar School	Silence Zone	50	40	30.73	36.19
4	Lakshmipura Village	Residential Area	55	45	32.75	34.43

Graphical representative of noise results for third season is given in Figure 4.15

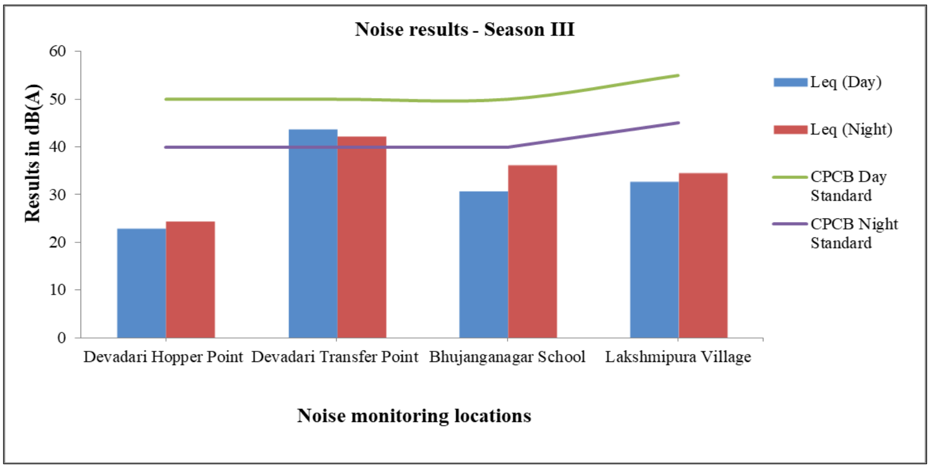


Figure 4.15 Graphical representation of noise results – season III

4.1.4.4 Seasonal variation – Noise

Noise was not monitored for 24h during first season. However, in season II and III, 24h monitoring was done for two non-consecutive days. The results were compared to CPCB standards. It revealed that the noise levels monitored were well within standards in all locations except Devadari transfer point in season III. This might be due to minor construction activities and also due to blasting activities in the region.

4.1.5 ToR V – Soil quality

4.1.5.1 Season I

During season I, soil samples were collected from Lakshmipura, Seenibasappa camp, Bhujanganagar and Narasapura and the results are given in Table 4.18.

Table 4.14 Results of soil quality for season I

Sl No	Parameters	Units	Lakshmipura	Seenibasappa camp	Bhujanganagar	Narasapura
1	Bulk density	g/cm^3	1.22	1.33	1.27	1.24
2	Porosity	%	53.96	19.05	52.07	53.2
3	pH	--	7.29	7.86	7.38	7.84
4	Electrical Conductivity	µS/cm	101	196	315	337
5	Calcium	meq/100g	98	123	139	228
6	Magnesium	meq/100g	18	23	74	48
7	Sodium	meq/100g	0.36	1.19	0.67	1.06
8	Potassium	mg/kg	1500	1150	1900	2600
9	Chloride	meq/100g	1.6	1.2	0.4	0.4
10	Nitrate	mg/kg	8.90	7.56	4.58	10.78
11	Sulphate	mg/kg	41.61	59.49	29.93	40.51
12	Phosphate	mg/kg	57.87	55.71	28.92	24.63
13	Water Holding Capacity	%	57.5	60	56.7	60
14	Sodium Adsorption Ratio	--	0.06	0.19	0.09	0.12
15	Exchangeable Sodium Percentage	%	0.022	0.091	0.031	0.036
16	Sand	%	62.2	47.6	65	61.8
17	Silt	%	9.2	38	15	16.9
18	Clay	%	28.3	14.2	30	21.1
19	Organic Carbon	%	0.47	0.53	0.54	0.56
20	Organic Matter	%	0.82	0.96	0.94	0.97

pH in the study area ranged between 7.29 to 7.86. Highest pH was recorded at Seenibasappa camp - 7.86 and overall soil pH in the study area was found to be alkaline. Graphical representation is given in Figure 4.16.

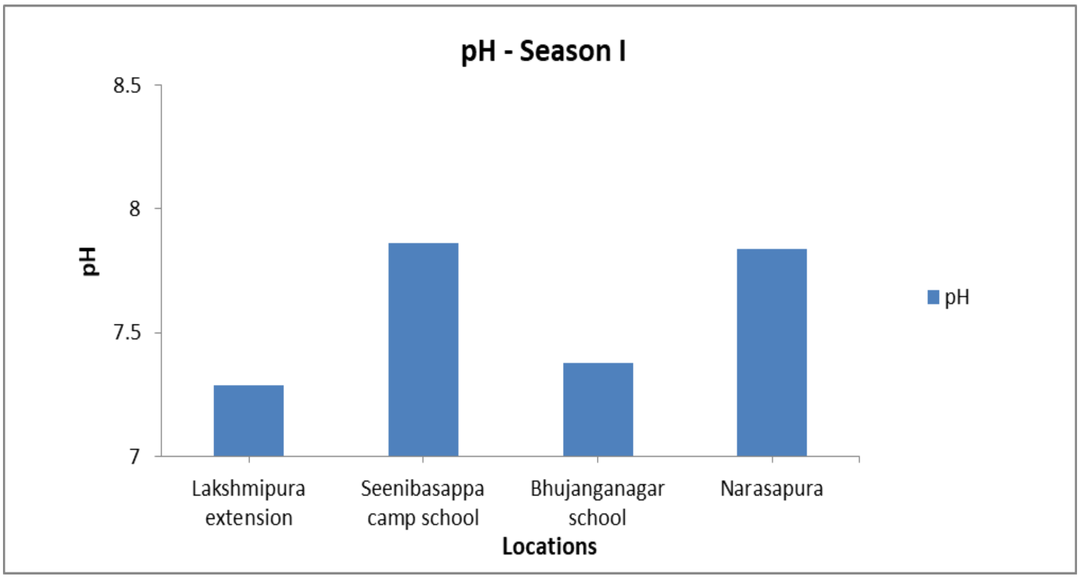


Figure 4.16 Graphical representation of pH of season I

Electrical conductivity is the measure of amount of salts present in the soil. Electrical conductivity ranged from 101 to 337 µS/cm with highest observed in Narasapura 337 µS/cm. Results showed sufficient amount of salts in the soil samples of the study area. Graphical representation is given in Figure 4.17.

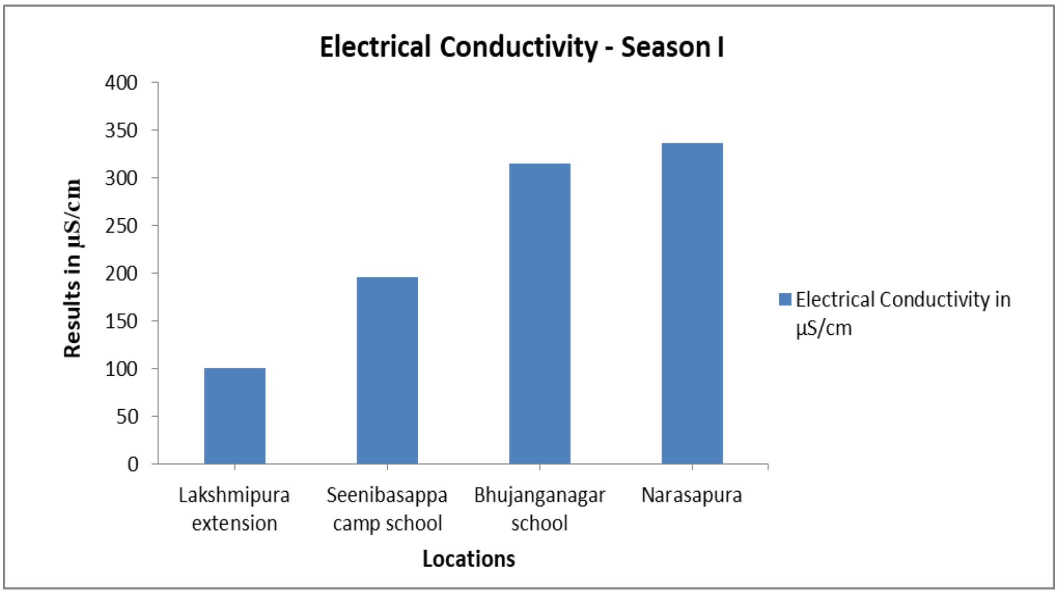


Figure 4.17 Graphical representation of Electrical Conductivity for season I

Sand, silt and clay content in soil samples ranged from 47.6% to 65%, 9.2% to 38% and 14.2% to 30%. Hydrological Soil Group (HSG) classification revealed that the soil present in the study area is Silt or Loam (HSG - B) as shown in Table 4.20. The classification of Hydrological Soil Group is based on Table 4.19. Graphical representation is given in Figure 4.18.

Table 4.15 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 %

Table 4.20 Sand and clay percentage and HSG classification

Sl No	Location	Sand (%)	Clay (%)	HSG
1	Lakshmipura Extension	62.2	28.3	Silt or Loam
2	Seenibasappa Camp - School	47.6	14.2	Silt or Loam
3	ChikkaSandur	65	20	Silt or Loam
4	Bhujanganagar School	61.8	21.1	Silt or Loam

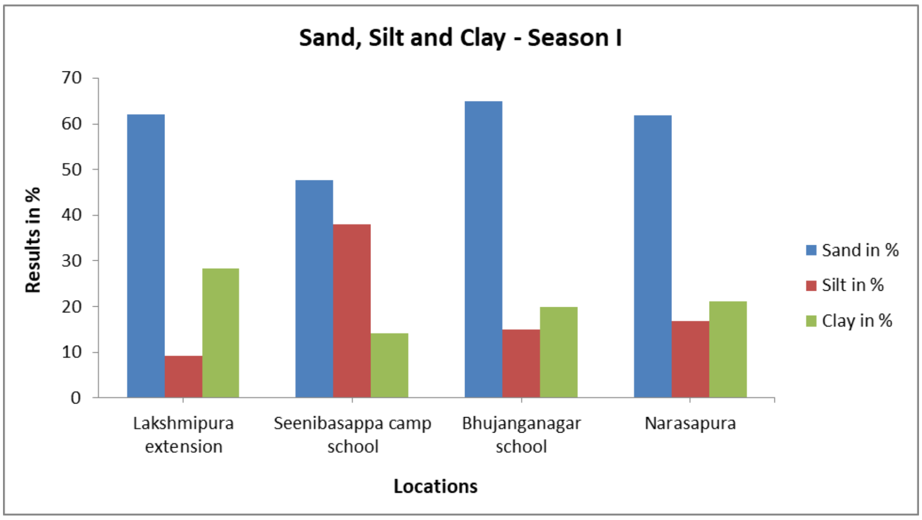


Figure 4.18 Results of Sand, silt and clay in season I

4.1.5.2 Season II

During the second season 4 sampling sites were identified viz., Lakshmipura extension, Seenibasappa camp, ChikkaSandur and Bhujanganagar School. The samples were collected and analysed. The results are given in Table 4.21.

Table 4.21 Results of soil quality for season II

Sl No	Parameters	Units	Lakshmipura Extension	Seenibasappa camp - School	ChikkaSandur	Bhujanganagar School
1	Bulk density	g/cm^3	1.449	1.297	1.305	1.343
2	Porosity	%	45.31	51.04	50.75	49.32
3	pH	--	8.16	7.91	7.18	8.28
4	Electrical Conductivity	µS/cm	250	302	99	206
5	Sodium	ppm	280	195	140	195
6	Phosphate	mg/kg	40.71	15.12	112.5	20.37
7	Potassium	ppm	210	240	145	265
8	Calcium	meq/100g	142	170	183	189
9	Magnesium	meq/100g	83	105	61	21
10	Chloride	ppm	0.99	11.99	4.99	12.99
11	Nitrate	mg/kg	15.60	5.63	21.3	7.65
12	Sulphate	mg/kg	57.74	81.17	23.72	39.78
13	Water Holding Capacity	%	53.33	53.33	63.33	50
14	Sodium Adsorption Ratio	%	0.363	0.229	0.174	0.262
15	Exchangeable Sodium Percentage	%	0.54	0.31	0.25	0.40
16	Sand	%	74.00	70.98	65.00	63.33
17	Silt	%	18.50	22.83	23.50	28.00
18	Clay	%	7.50	6.19	11.50	8.67
19	Organic Carbon	%	2.40	3.11	2.37	2.16
20	Organic Matter	%	4.14	5.36	4.08	3.73

pH in the study area ranged between 7.18 to 8.28. Highest pH was recorded at Bhujanganagar school 8.28 and overall soil pH in the study area was found to be near neutral to alkaline. Graphical representation is given in Figure 4.19.

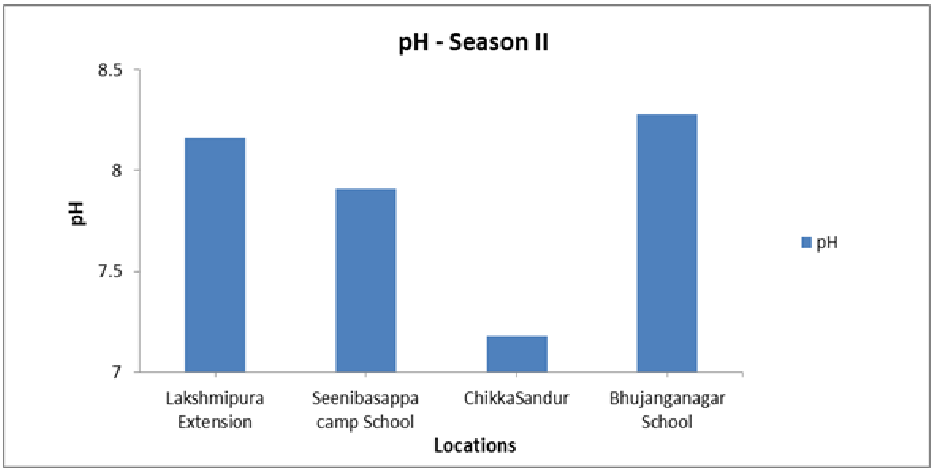


Figure 4.19 Graphical representation of pH in season II

Electrical conductivity is the measure of amount of salts present in the soil. Electrical conductivity ranged from 99 to 302 µS/cm with highest observed in Seenibasappa camp 302 µS/cm. Results showed sufficient amount of salts in the soil samples of the study area. Graphical representation is given in Figure 4.20.

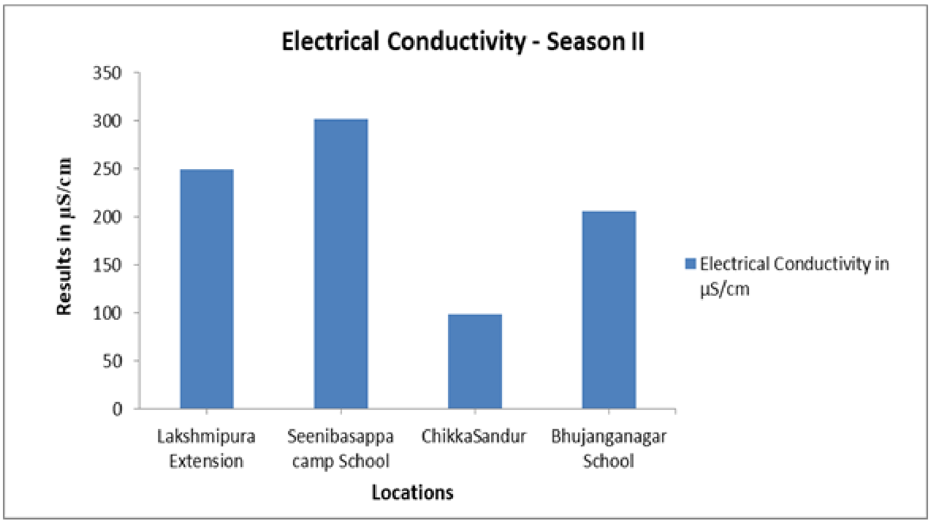


Figure 4.20 Graphical representation of Electrical conductivity for season II

Sand, silt and clay content in soil samples ranged from 63.3% to 74%, 18.5% to 28% and 6.1% to 11.5%. HSG classification revealed that the soil present in the study area is Silt or Loam (HSG - B) as shown in Table 4.22 and the classification was based on Table 4.19. Graphical representation is given in Figure 4.21.

Table 4.22 Sand, clay percentage and HSG classification

Sl No	Location	Sand (%)	Clay (%)	HSG
1	Lakshmipura Extension	74	7.5	Silt or Loam
2	Seenibasappa Camp - School	70.98	6.19	Silt or Loam
3	ChikkaSandur	65	11.5	Silt or Loam
4	Bhujanganagar School	63.33	8.67	Silt or Loam

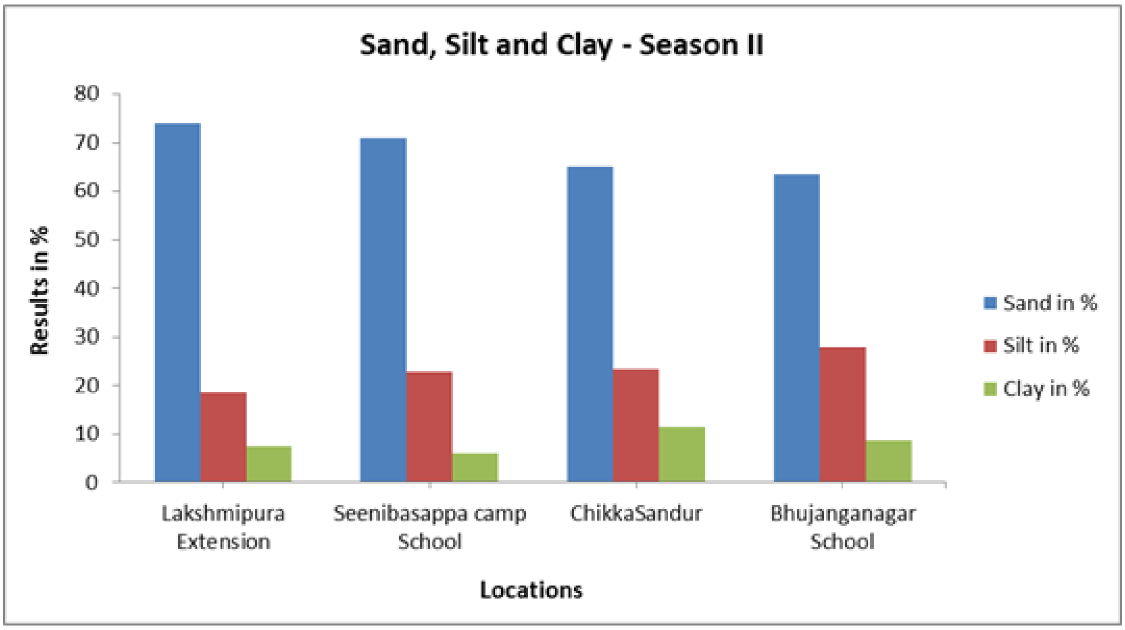


Figure 4.21 Graphical representation of sand, silt and clay for season II

4.1.5.3 Season III

During the third season 4 sampling sites were identified viz., Lakshmipura extension, Seenibasappa camp, ChikkaSandur and Bhujanganagar School. The samples were collected and analysed. The results are given in Table 4.23.

Table 4.16 Results of soil quality for season III

Sl No	Parameters	Units	Lakshmipura Extension	Seenibasappa camp - School	Chikka Sandur	Bhujanganagar School
1	Bulk density	g/cm^3	1.23	1.29	1.13	1.23
2	Porosity	%	53.6	51.3	57.4	53.6
3	pH	--	7.29	7.23	7.1	7.01
4	Electrical Conductivity	µS/cm	291	308	326	210
5	Calcium	meq/100g	155	240	280	545
6	Magnesium	meq/100g	30	35	95	50
7	Sodium	meq/100g	4.65	3.78	2.78	74.6
8	Potassium	ppm	976	1272	1224	1136
9	Chloride	meq/100g	BDL	0.6	0.3	0.7
10	Nitrate	mg/kg	9.16	6.88	11.32	8.55
11	Sulphate	mg/kg	74.68	139.3	30.16	40.69
12	Phosphate	mg/kg	32.48	46.86	32.97	55.04
13	Water Holding Capacity	%	53.6	52	62.4	47.6
14	Sodium Adsorption Ratio	--	0.7	0.5	0.3	6.1
15	Exchangeable Sodium Percentage	%	0.4	0.2	0.2	4.1
16	Sand	%	57.1	66.7	72	63.1
17	Silt	%	28.6	21.1	24	32.4
18	Clay	%	14.3	12.2	4	4.5
19	Organic Carbon	%	0.97	1.25	0.87	0.8
20	Organic Matter	%	1.68	2.16	1.5	1.38

pH in the study area ranged between 7.01 to 7.29. Highest pH was recorded at Lakshmipura extension (7.29) and overall soil pH in the study area was found to be near neutral. Graphical representation is given in Figure 4.22.

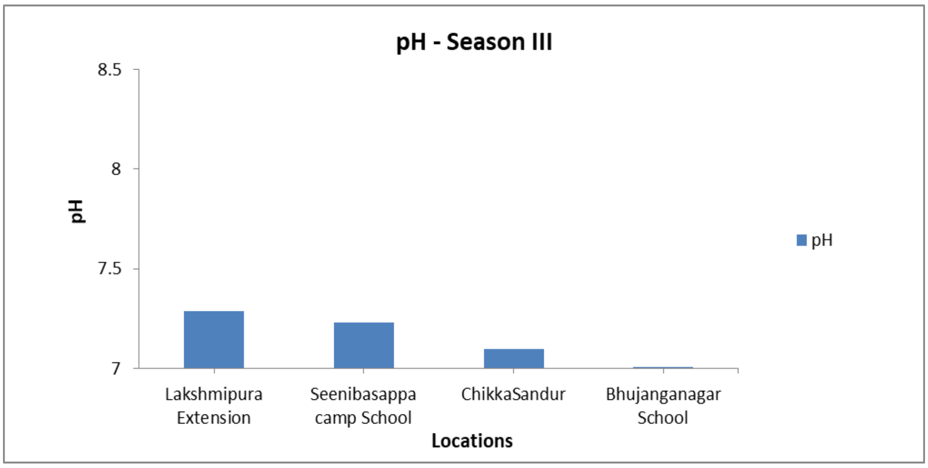


Figure 4.22 Graphical representation of pH for season III

Electrical conductivity is the measure of amount of salts present in the soil. Electrical conductivity ranged from 210 to 326 µS/cm with highest observed in ChikkaSandur (326 µS/cm). Results showed sufficient amount of salts in the soil samples of the study area. Graphical representation is given in Figure 4.23.

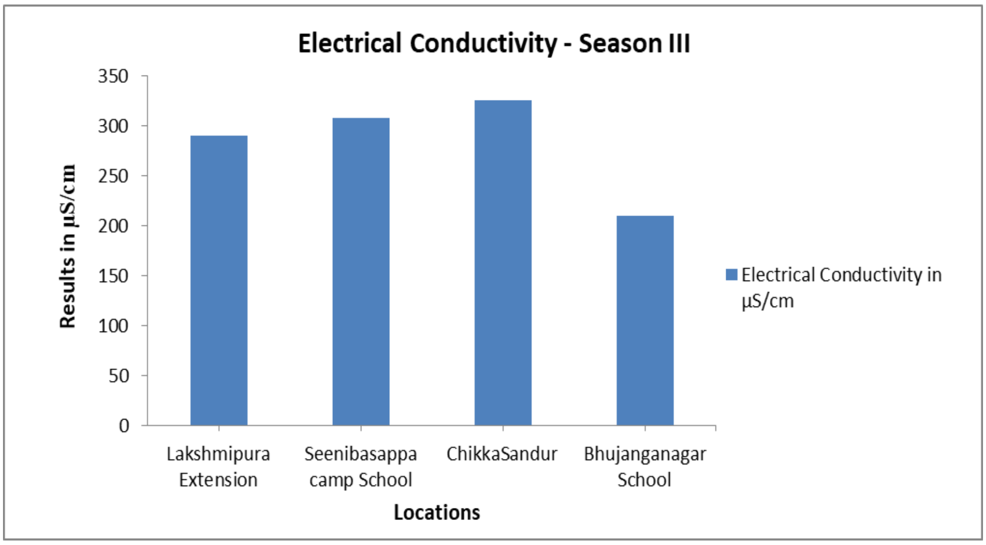


Figure 4.23 Graphical representation of Electrical Conductivity for season III

Sand, silt and clay content in soil samples ranged from 57.1% to 72%, 21.1% to 32.4% and 4% to 14.3%. Hydrological Soil Group (HSG) classification revealed that the soil present in the study area is Silt or Loam (HSG - B) as shown in Table 4.24 and the classification was based on Table 4.19. Graphical representation is given in Figure 4.24.

Table 4.17 Sand, clay percentage and HSG classification

Sl No	Location	Sand (%)	Clay (%)	HSG
1	Lakshmipura Extension	57.1	14.3	Silt or Loam
2	Seenibasappa Camp - School	66.7	12.2	Silt or Loam
3	ChikkaSandur	72	4	Silt or Loam
4	Bhujanganagar School	63.1	4.5	Silt or Loam

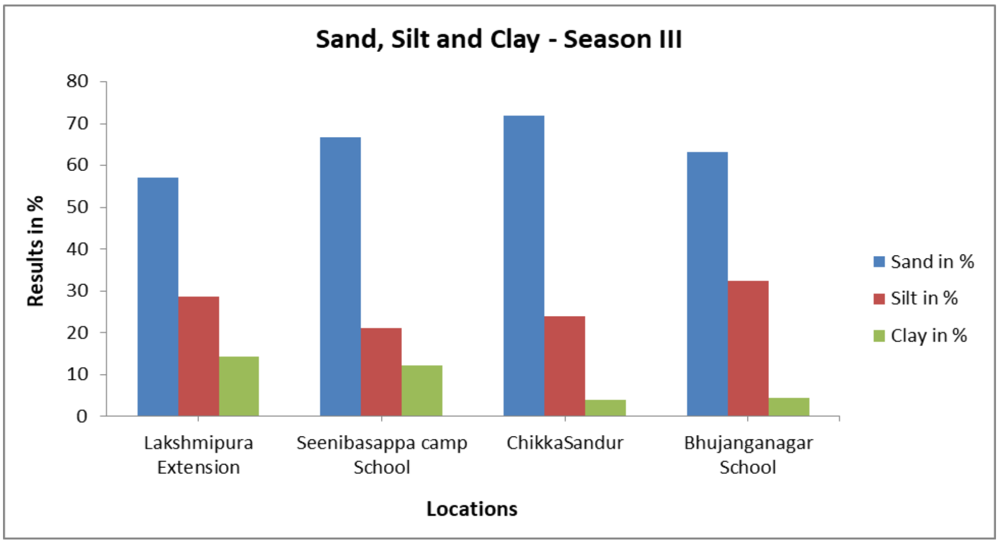


Figure 4.24 Graphical representation of sand, silt and clay for season III

4.1.5.4 Discussion

In all seasons the soil pH was found to be alkaline. Higher Electrical Conductivity was observed in all samples and seasons. Hydrological Soil Group classification revealed that Silt or Loam type of soil is predominantly present in the study area.

4.1.6 ToR VI - Meteorological monitoring

4.1.6.1 Season I

During first season, secondary data was gathered from M/s JSW, Ballari. The data collected is provided as Annexure IV.

4.1.6.2 Season II

During second season, secondary data was gathered from M/s JSW, Ballari.. The data collected is provided as Annexure IV.

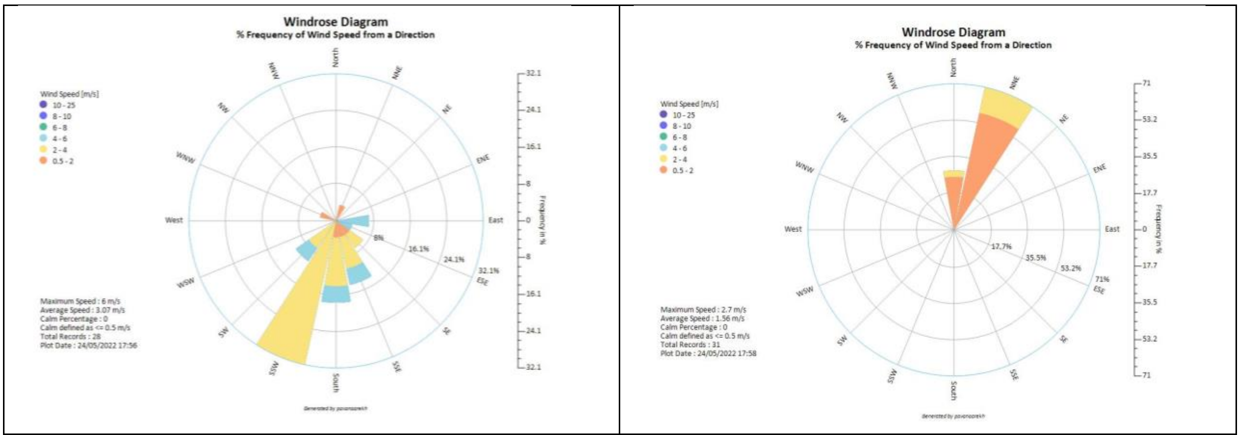
4.1.6.3 Season III

During third season secondary primary data was gathered from the meteorological stations installed by EMPRI. The results are given in Table 4.25.

Table 4.18 Results of meteorological data for season III

Sl No	Month	Year		Temperature (°C)	Rainfall (mm)	Humidity (%)	Wind speed (m/s)	Dominant wind direction
1	February	2022	Max	31.8	0	98.8	5.6	South-South-West (SSW)
			Min	12.3	0	57.5	1.1	
			Avg	-	0	78.41	3.07	
2	March	2022	Max	37.4	0	100	2.4	North-North-East (NNE)
			Min	17.1	0	55.5	0.6	
			Avg	-	0	87	1.56	

The maximum temperature recorded in Devadari DHPC study area is 37.4ºC on 31.03.2022 and minimum temperature is 12.3ºC on 04.02.2022. Relative humidity was found to be minimum (55.5 %) and maximum (100%) on 12th and 16th March 2022 respectively. Wind rose plot for Devadari DHPC is given in Figure 4.25. Predominant wind direction was found to be towards South-South-West during February 2022 and North-North-East during March 2022.



February-2022	March-2022

Figure 4.25 Wind rose plot for season III

5 Tunga and Bhadra DHPC

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

5.1 Results

5.1.1 ToR I – Inventorisation of waterbodies

Satellite imageries were used to identify the water bodies in the study area and field visits were done for ground truth verification of the same.

5.1.1.1 Season I

In the first season, water bodies were inventoried in 10 km radius of Tunga & Bhadra DHPC and results are given in Table 5.1.

Table 5.1 List of water bodies inventoried during season I

Sl No	Surface water bodies	Distance from Tunga & Bhadra DHPC (km)	Remarks	GPS Coordinates	
				Latitude	Longitude
1	Narihalla	5.95	Perennial	15º 7' 0" N	76º 34' 36" E
2	Ubbalagandi Nalla	9.90	Seasonal	15° 3' 8.784" N	76° 39' 13.4244" E
3	Rajapura Kere	9.96	Seasonal	15°7'6.68" N	76°41'4.3332" E
4	Avinamadugu Kere	8.69	Seasonal	15° 5' 6.828" N	76° 43' 58.818" E

Four water bodies were found in the study area out of which three were seasonal water bodies and one was perennial water body.

5.1.1.2 Season II and III

In second and third season, water bodies were inventoried considering 2 km area on either side of Tunga & Bhadra DHPC and through ground truth verification, no active water bodies were found in the study area.

5.1.2 ToR II – Surface and Groundwater

5.1.2.1 Season I (Surface water)

During first season only Narihalla surface water sample was collected since its perennial. Results are given in Table 4.3 and compared with designated water quality criteria.

5.1.2.2 Season II and III

Water samples were not collected due to the absence of surface water bodies in 2 km area on either side of Tunga & Bhadra DHPC.

5.1.2.3 Discussion

No active water bodies were found in second and third season due to change in sampling area from 10 km to 2 km.

5.1.2.4 Season I (Groundwater)

During first season, three groundwater samples were collected and analysed in the laboratory. Results are given in Table 5.2 and compared with Drinking water quality standards.

Table 5.2 Results of groundwater quality sample of season I

Sl No	Particulars	Units	Std. IS 10500:2012*		Bannihatti	Lingadahalli	Taranagar
			AL*	PL*			
1	pH	--	6.5 - 8.5	NR	7.5	7.4	7.3
2	Odour		Agreeable		Odourless	Odourless	Odourless
3	Colour	Hazen	5	15	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	1398	1587	2116
5	Chlorides	mg/L	250	1000	397.4	269.9	559.8
6	Sulphate	mg/L	200	400	261.6	261.6	261.6
7	Fluoride	mg/L	1	1.5	BDL	0.83	BDL
8	Boron	mg/L	0.5	1	1.11	BDL	0.05
9	Calcium	mg/L	75	200	168.3	234.4	288.5
10	Sodium	mg/L	--		113	70	92
11	Iron	mg/L	0.3	NR	0.4895	0.2294	0.7874
12	Turbidity	mg/L	1	5	0.3	1.2	0.4
13	Total Hardness	mg/L	200	600	605	915	1180
14	Magnesium	mg/L	30	100	44.9	80.1	111.7
15	Nitrate	mg/L	45	NR	22.91	18.17	23
16	Total Alkalinity	mg/L	200	600	305	410	340
17	Potassium	mg/L	--		6.8	02	8.8
18	Copper	mg/L	0.05	1.5	BDL	BDL	BDL
19	Manganese	mg/L	0.1	0.3	BDL	BDL	BDL
20	Zinc	mg/L	5	15	0.2293	BDL	0.05
21	Cadmium	mg/L	0.003	NR	0.0538	0.05	0.0544
22	Lead	mg/L	0.01	NR	BDL	BDL	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	0.010	BDL	BDL
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		920	1600	1600

Note: AL- Acceptance Limit, PL- Permissible Limit, OL- Odourless, BDL- Below Detection Limit, NR- No Relaxation, S- Season, MPN- Most Probable Number; mg/L- Milligram per Litre.

Graphical representation of the Total hardness, Calcium and Magnesium is given in Figure 5.1 to show the balanced ratio (TH ≥ Ca + Mg).

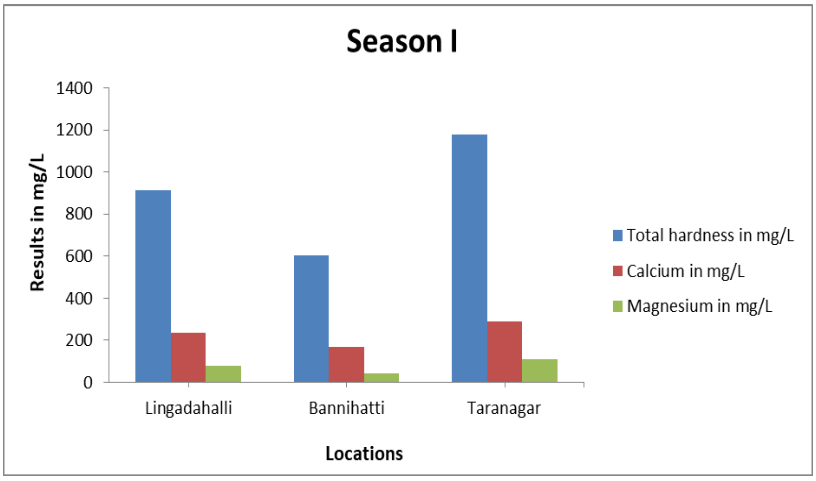


Figure 5.1 Graphical representation of TH, Ca and Mg for season I

Total hardness and heavy metals like Iron, Aluminium, Boron and Cadmium was found exceeding the permissible limit. The Ground Water Quality Index (GWQI) during season I ranged between good (B grade) to poor (C grade). Except Lingadahalli (i.e, Good - B grade), remaining two locations (Bannihatti and Taranagar) showed higher values (Poor - C grade) and graphical representation of the same is given in Figure 5.2.

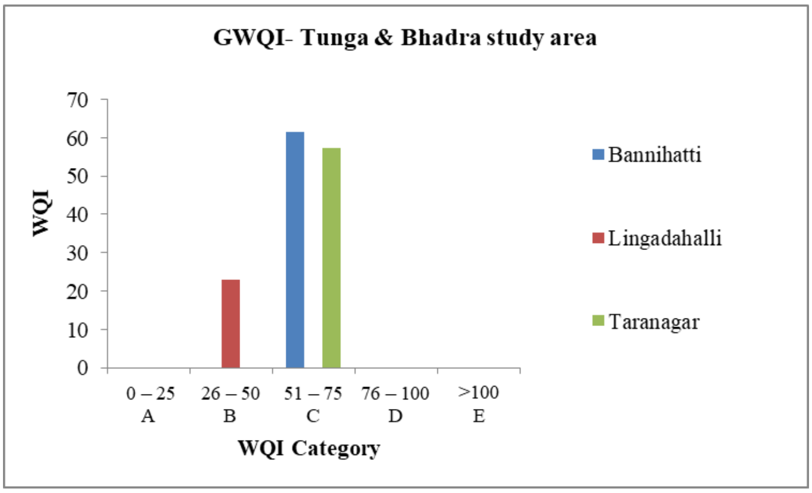


Figure 5.2 Graphical representation of Ground water quality index for season I

5.1.2.5 Season II

During second season, four groundwater samples were collected and analysed in the laboratory. Results are given in Table 5.3 and compared with Drinking water quality standards.

Table 5.3 Results of groundwater quality samples for season II

Sl No	Particulars	Units	Std. IS 10500:2012*		Tunga & Bhadra Sponge Factory	Tunga & Bhadra Road Intersect	Bannihatti Transfer Point	Bannihatti School
			AL*	PL*				
1	pH	--	6.5- 8.5	NR	6.62	6.64	6.64	6.75
2	Odour		Agreeable		OL	OL	OL	OL
3	Colour	Hazen	5	15	1	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	715	765	642.4	719.6
5	Chlorides	mg/L	250	1000	54.9	34.9	44.9	84.9
6	Sulphate	mg/L	200	400	109.8	46.32	43.2	51.59
7	Fluoride	mg/L	1	1.5	BDL	BDL	BDL	BDL
8	Boron	mg/L	0.5	1	0.33	0.2	0.39	0.2
9	Calcium	mg/L	75	200	132.2	108.2	196.3	172.3
10	Sodium	mg/L	--		83	59	67	67
11	Iron	mg/L	0.3	NR	0.23	0.25	0.29	0.13
12	Turbidity	mg/L	1	5	0.16	0.24	0.08	0.06
13	Total Hardness	mg/L	200	600	540	450	530	550
14	Magnesium	mg/L	30	100	51	43.7	9.7	29.1
15	Nitrate	mg/L	45	NR	BDL	1.1	BDL	BDL
16	Total Alkalinity	mg/L	200	600	412	430	438	396
17	Potassium	mg/L	--		BDL	BDL	BDL	BDL
18	Copper	mg/L	0.05	1.5	BDL	BDL	BDL	BDL
19	Manganese	mg/L	0.1	0.3	BDL	BDL	BDL	BDL
20	Zinc	mg/L	5	15	BDL	0.29	0.61	BDL
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL	BDL
22	Lead	mg/L	0.01	NR	0.06	0.1	0.06	0.08
23	Total Chromium	mg/L	0.05	NR	BDL	BDL	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	0.331	0.046	0.234	0.111
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	0.003	0.046	0.002	0.002
28	Total Coliform	MPN/ 100 mL	Nil		1600	23	<1.8	920

Note: AL- Acceptance Limit, PL- Permissible Limit, OL- Odourless, BDL- Below Detection Limit, NR- No Relaxation, S- Season, MPN- Most Probable Number; mg/L- Milligram per Litre.

Graphical representation of the Total hardness, Calcium and Magnesium is given in Figure 5.3 to show the balanced ratio (TH ≥ Ca + Mg).

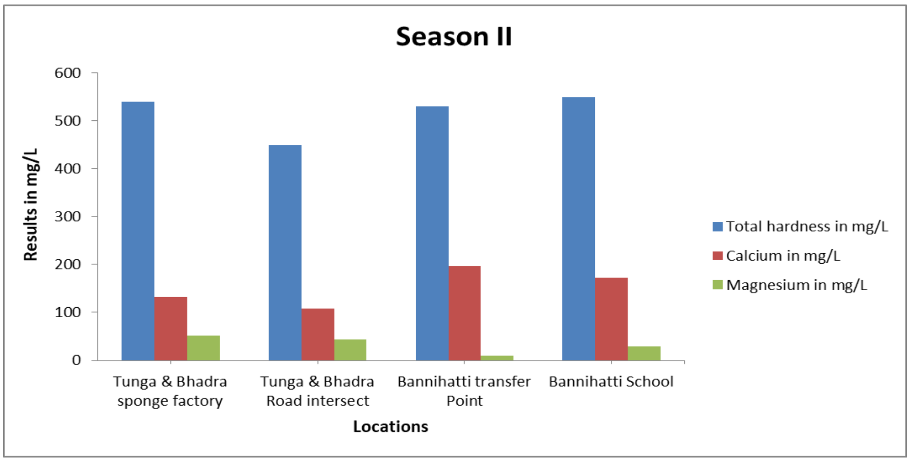


Figure 5.3 Graphical representation of TH, Ca and Mg for season II

Aluminium, Lead and Total Arsenic concentration exceeded the permissible limit. The Ground Water Quality Index (GWQI) during season II ranged between excellent (A grade) to poor (C grade). Although the grades vary, all sites are commonly found to have high alkalinity and hardness exceeding the acceptable limit. Graphical representation of the same is given in Figure 5.4.

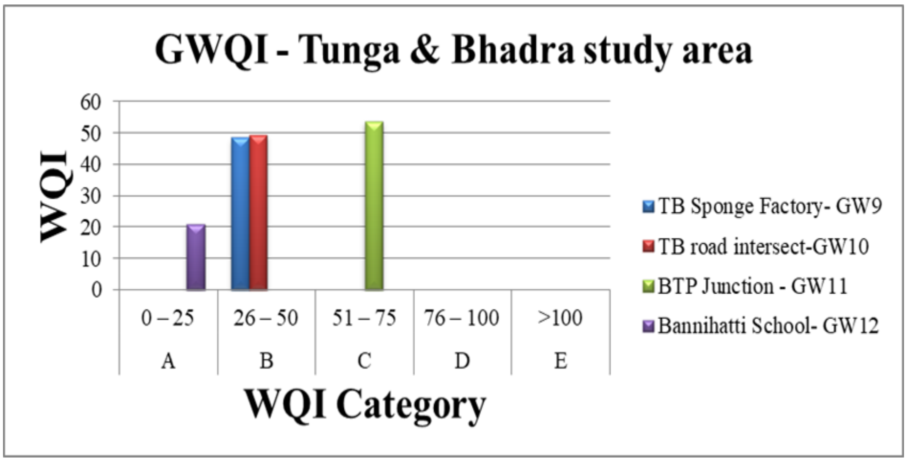


Figure 5.4 Graphical representation of GWQI for season II

5.1.2.6 Season III

During third season, four groundwater samples were collected and analysed in the laboratory. Results are given in Table 5.4 and compared with drinking water quality standards.

Table 5.4 Results of groundwater quality samples for season III

Sl No	Particulars	Units	Std. IS 10500:2012*		Tunga & Bhadra Sponge Factory	Tunga & Bhadra Road Intersect	Bannihatti Transfer Point	Bannihatti School
			AL*	PL*				
1	pH	--	6.5 - 8.5	NR	7.5	7.6	7.6	7.5
2	Odour		Agreeable		OL	OL	OL	OL
3	Colour	Hazen	5	15	1	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	783.2	600	666.4	769.8
5	Chlorides	mg/L	250	1000	54.9	34.9	39.9	69.9
6	Sulphate	mg/L	200	400	93.7	34.1	34.4	53.9
7	Fluoride	mg/L	1	1.5	0.77	0.79	0.96	0.69
8	Boron	mg/L	0.5	1	0.05	0.14	0.07	0.05
9	Calcium	mg/L	75	200	113.9	121.8	133.5	145.3
10	Sodium	mg/L	--		49	27	23	43
11	Iron	mg/L	0.3	NR	0.16	0.09	0.11	0.12
12	Turbidity	mg/L	1	5	0.06	0.08	0.12	0.06
13	Total Hardness	mg/L	200	600	515	545.9	556.2	700.4
14	Magnesium	mg/L	30	100	56.1	58.8	54.2	82.1
15	Nitrate	mg/L	45	NR	7.2	4.4	9.5	9.5
16	Total Alkalinity	mg/L	200	600	316	384	320	356
17	Potassium	mg/L	--		3.6	0.8	1.6	4.8
18	Copper	mg/L	0.05	1.5	0.05	0.05	BDL	BDL
19	Manganese	mg/L	0.1	0.3	BDL	BDL	BDL	BDL
20	Zinc	mg/L	5	15	0.4	0.11	2.05	BDL
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL	BDL
22	Lead	mg/L	0.01	NR	0.13	0.08	0.11	0.16
23	Total Chromium	mg/L	0.05	NR	BDL	BDL	BDL	BDL
24	Mercury	mg/L	0.001	NR	0.026	0.022	0.012	BDL
25	Aluminium	mg/L	0.003	NR	0.253	0.511	0.417	0.291
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL	BDL

Sl No	Particulars	Units	Std. IS 10500:2012*		Tunga & Bhadra Sponge Factory	Tunga & Bhadra Road Intersect	Bannihatti Transfer Point	Bannihatti School
			AL*	PL*				
27	Total Arsenic	mg/L	0.01	0.05	BDL	0.004	0.003	BDL
28	Total Coliform	MPN/ 100mL	Nil		<1.8	6.8	<1.8	94
Note: AL- Acceptance Limit, PL- Permissible Limit, OL- Odourless, BDL- Below Detection Limit, NR- No Relaxation, S- Season, MPN- Most Probable Number; mg/L- Milligram per Litre.								

Graphical representation of the Total hardness, Calcium and Magnesium is given in Figure 5.5 to show the balanced ratio (Total Hardness ≥ Calcium + Magnesium).

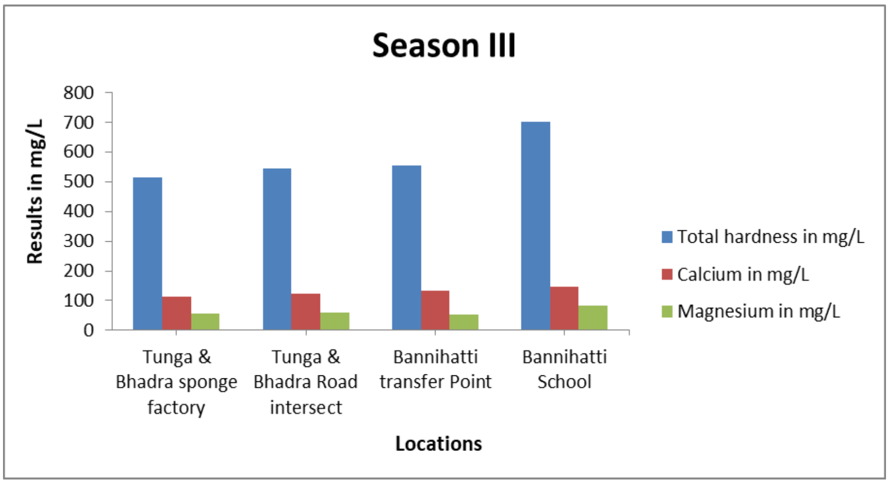


Figure 5.5 Graphical representation of TH, Ca and Mg for season III

Heavy metals like Aluminium, Lead and Mercury were found exceeding the permissible limit. The Ground Water Quality Index (GWQI) during season III ranged between excellent (A grade) to good (B grade). Tunga & Bhadra sponge factory recorded higher values (i.e, Good - B grade) compared to other locations and graphical representation of the same is given in Figure 5.6.

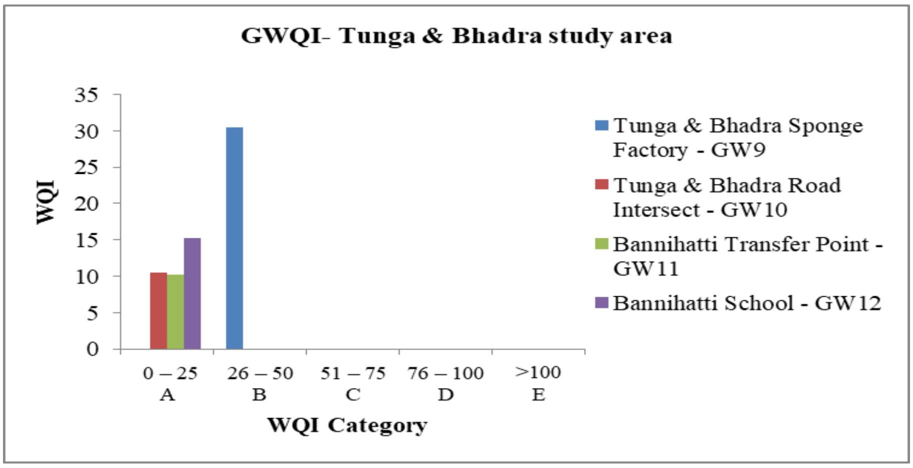


Figure 5.6 Graphical representation of GWQI for season III

5.1.2.7 Discussion

In all three seasons, higher level of hardness was observed which do not cause health effects on humans but results in scale formation. Fluoride content was found to be below acceptable limit in all samples and seasons. Heavy metals like Iron, Aluminium, Lead, Cadmium, Boron, Mercury and Total Arsenic was found exceeding the permissible limit. In season I, II and III the GWQI ranged from B-C, A-C and A-B respectively. Except Bannihatti transfer point (i.e., C – Poor) (season II) in the remaining locations, seasons fall under either A – excellent or B – good category.

5.1.3 ToR III – Ambient air quality

5.1.3.1 Season I

In first season, ambient air monitoring was carried out at only one location that is Bannihatti school and results are given in Table 5.5. Since monitoring was not carried out for 24 h due to rain hence the results were not compared with NAAQS. Particulate Matter - 2.5 was not monitored.

Table 5.5 Results of ambient air in season I

Sl No	Location	GPS Coordinates		SO_2 (µg/m^3)	NO_2 (µg/m^3)	PM_{10} (µg/m^3)
		Latitude	Longitude			
1	Bannihatti School	15º9' 16.74"N	76º36'54"E	BDL	BDL	3.76
2	Bannihatti School	15º9' 16.74"N	76º36'54"E	BDL	BDL	26.4
3	Bannihatti School	15º9' 16.74"N	76º36'54"E	BDL	BDL	25.8
4	Bannihatti School	15º9' 16.74"N	76º36'54"E	BDL	BDL	41.8

5.1.3.2 Season II

In second season, ambient air monitoring was carried out at five locations and results are given in Table 5.6. Results are compared with National Ambient Air Quality Standards.

Table 5.6 Results of ambient air in season II

Sl No	Particular	PM_{10}	$PM_{2.5}$	SO_2	NO_2
	Units	**µg/m^3**	**µg/m^3**	**µg/m^3**	**µg/m^3**
NAAQ Standards (µg/m^3)		**100**	**60**	**80**	**80**
1	Bannihatti Transfer Point	166.85	69.63	62.23	1.77
2	Road Intersect Point	231.15	31.22	78.24	1.39
3	1st Pillar Point	203.47	39.55	536.47	7.92
4	Bhadra Hopper Point	318.11	65.54	89.11	0.4
5	Bannihatti School	112.3	25.51	110.62	1.65
Note: µg/m^3 - Microgram per metre cube.					

Graphical representation of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 for season II is given in Figure 5.7, 5.8, and 5.9 respectively.

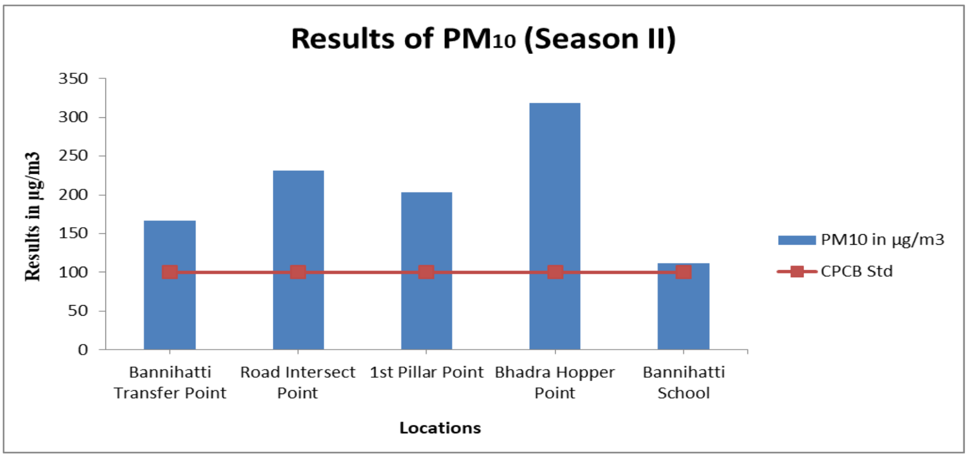


Figure 5.7 Graphical representation of PM_{10} for season II

During season II, Particulate Matter – 10 (PM_{10}) concentrations exceeded the National Ambient Air Quality Standards in all five locations due to vehicular movement which in turn increased the dust level and resulted in spike of Particulate Matter – 10 concentrations.

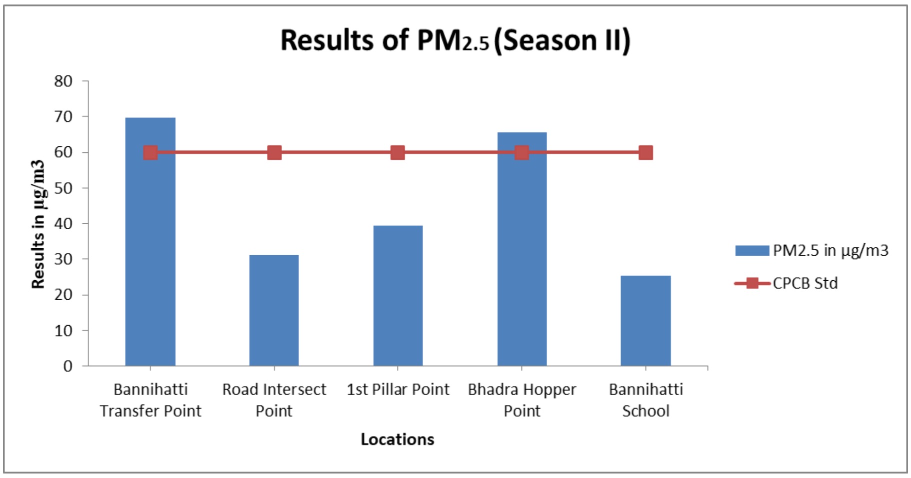


Figure 5.8 Graphical representation of $PM_{2.5}$ for season II

During season II, Particulate Matter – 2.5 ($PM_{2.5}$) concentrations exceeded the National Ambient Air Quality Standards in Bannihatti transfer point and Bhadra hopper point. This is due to dust raised from transportation of Iron ore through trucks and mining activities (loading, unloading, crushing, drilling, blasting etc) in the study area.

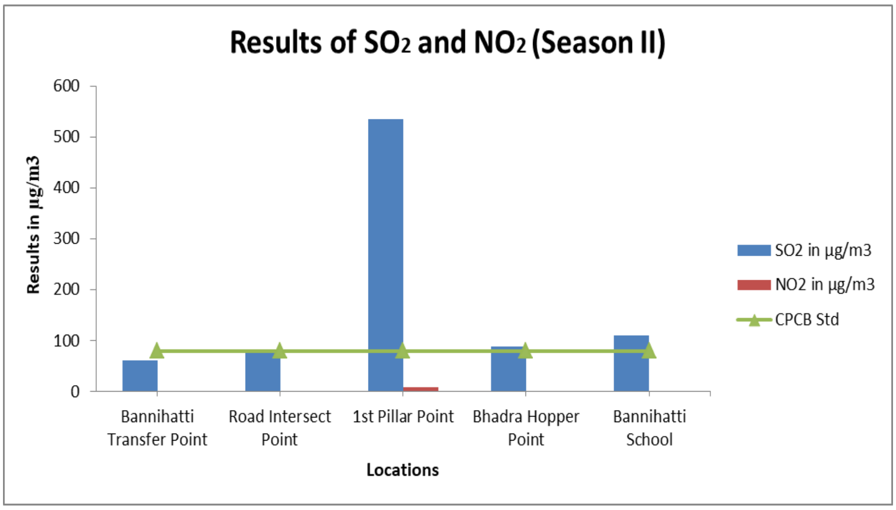


Figure 5.9 Graphical representation of SO_2 and NO_2 for season II

During season II, Sulphur dioxide (SO_2) concentration exceeded the National Ambient Air Quality Standards in Road intersect point, 1st pillar point, Bhadra hopper point and Bannihatti School due to increased vehicular emissions from the movement of vehicles. Nitrogen dioxide concentration in all five locations was found to be within the National Ambient Air Quality Standards.

During second season, Air Quality Index of five locations was calculated using Central Pollution Control Board AQI calculator. The AQI category is given in Table 5.7.

Table 5.7 AQI category as per CPCB

Sl No	Air Quality Index	Category
1	0 - 50	Good
2	51 - 100	Satisfactory
3	101 - 200	Moderate
4	201 - 300	Poor
5	301 - 400	Very poor
6	>401	Severe

Results revealed that in season II AQI ranged from moderate to poor category in the study area and the same is given in Table 5.8.

Table 5.8 Air quality index for season II

Sl No	Location Name	AQI	Category
1	Bannihatti Transfer Point	145	Moderate
2	Road Intersect Point	191	Moderate
3	1st Pillar Point	237	Poor
4	Bhadra Hopper Point	268	Poor
5	Bannihatti School	110	Moderate

5.1.3.3 Season III

In third season, ambient air monitoring was carried out at five locations and results are given in Table 5.9. Results are compared with National Ambient Air Quality Standards.

Table 5.9 Results of ambient air in season III

Sl No	Particular	PM_{10}	$PM_{2.5}$	SO_2	NO_2
	Units	µg/m^3	µg/m^3	µg/m^3	µg/m^3
	NAAQ Standards (µg/m^3)	100	60	80	80
1	Bannihatti Transfer Point	339.34	43.87	2.97	16.18
2	Road Intersect Point	408.26	88.14	2.47	32.78
3	1st Pillar Point	513.73	62.18	9.34	70.90
4	Bhadra Hopper Point	538.16	102.58	17.53	57.93
5	Bannihatti School	335.50	115.09	2.57	16.51
Note: µg/m^3 - Microgram per metre cube.					

Graphical representation of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 for season II is given in Figure 5.10, 5.11 and 5.12 respectively.

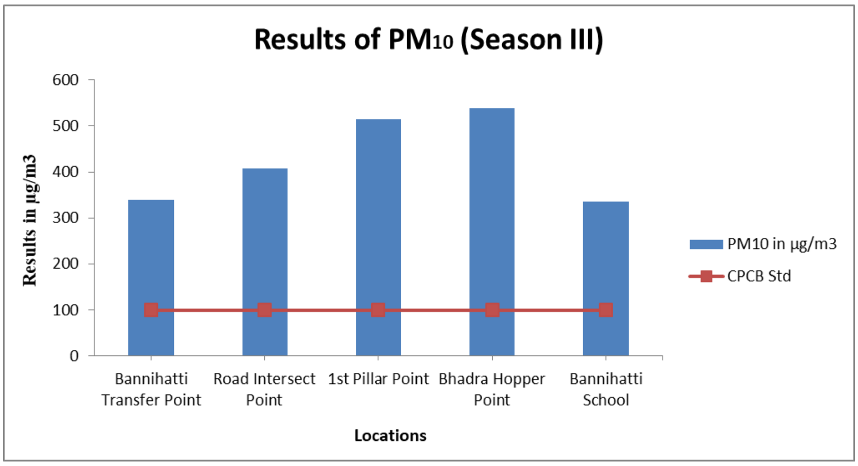


Figure 5.10 Graphical representation of PM_{10} for season III

During season III, PM_{10} concentration exceeded the National Ambient Air Quality Standards in all five locations due to vehicular movement which in turn increased the dust level and resulted in spike of Particulate Matter – 10 concentrations.

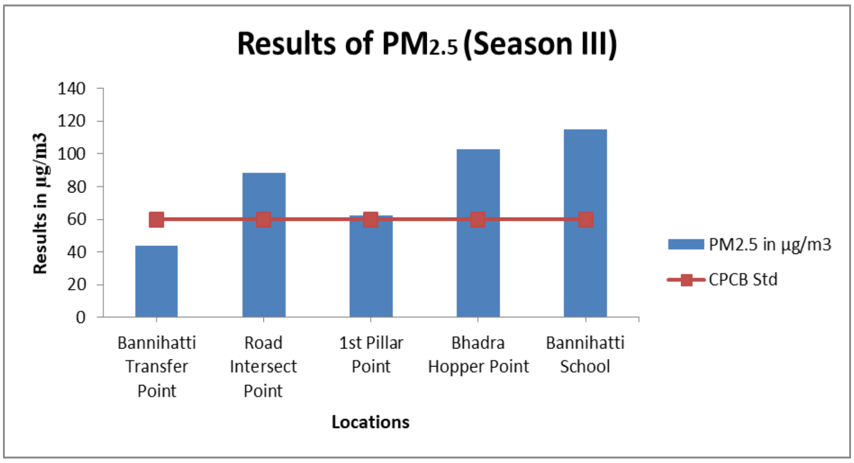


Figure 5.11 Graphical representation of $PM_{2.5}$ for season III

During season III, Particulate Matter – 2.5 ($PM_{2.5}$) concentration exceeded the National Ambient Air Quality Standards in Road intersect point, 1st pillar point, Bhadra hopper point and Bannihatti school due to dust raised from transportation of Iron ore through trucks and mining activities (loading, unloading, crushing, drilling, blasting etc) in the study area.

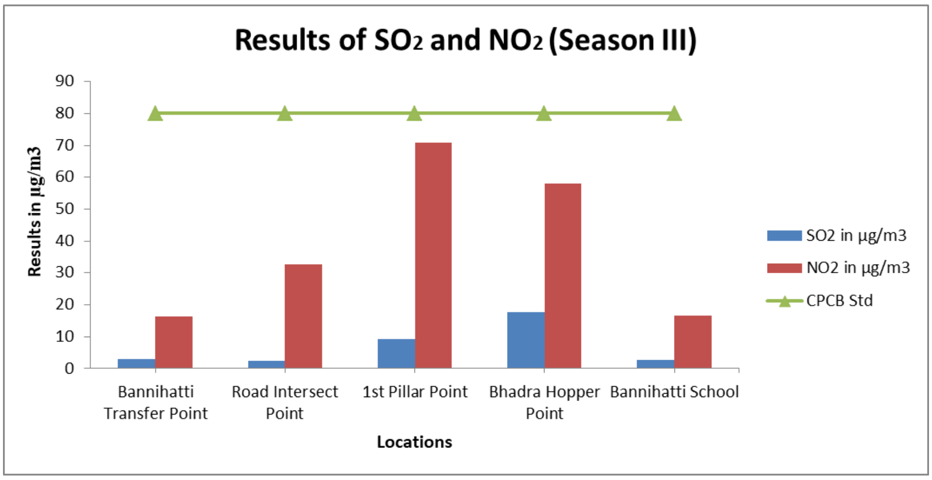


Figure 5.12 Graphical representation of SO_2 and NO_2 for season III

During season III, SO_2 and NO_2 concentration in all five locations was found to be within the National Ambient Air Quality Standards.

During third season, AQI of five locations was calculated using CPCB AQI calculator. Results revealed that in season III, AQI falls under poor to severe category in the study area as shown in Table 5.10.

Table 5.10 AQI for Season III

Sl No	Location Name	AQI	Category
1	Bannihatti Transfer Point	289	Poor
2	Road Intersect Point	373	Very Poor
3	1st Pillar Point	505	Severe
4	Bhadra Hopper Point	535	Severe
5	Bannihatti School	286	Poor

5.1.3.4 Discussion

Due to rain, air monitoring could not be carried in season I for 24 h, but in season II and III monitoring was done for 24 h and results were compared with National Ambient Air Quality Standards.

Results of season II revealed that PM_{10} concentrations in all five locations was above National Ambient Air Quality Standards.$PM_{2.5}$ concentration in Bannihatti transfer point, Bhadra hopper point and SO_2 concentration in 1st pillar point, Bannihatti transfer point and Bannihatti school were found to be above National Ambient Air Quality Standards. NO_2 concentration in all five locations was within the National Ambient Air Quality Standards.

In season III, PM_{10} concentrations in all five locations and $PM_{2.5}$ concentrations in four locations exceeded the National Ambient Air Quality Standards whereas SO_2 and NO_2 concentration in all five locations were within the National Ambient Air Quality Standards.

Irrespective of locations and seasons, the PM_{10} and $PM_{2.5}$ concentrations in the study area are high due to movement of trucks carrying Iron ore. The Air Quality Index of season II is better compared to that of season III.

5.1.4 ToR IV – Ambient noise quality

5.1.4.1 Season I

In first season, ambient noise monitoring was carried out in one location viz., Bannihatti School and results are given in Table 5.11. Since monitoring was not carried out for 24 h, due to rain, the results were not compared with CPCB Standards.

Table 5.11 Results of noise monitoring for season I

Time	Results dB(A)
6 Am	54.2
7 Am	47.3
8 Am	53.1
10 Am	46.6
11 Am	48.5
12 Pm	46.6
1 Pm	47.3
2 Pm	43.9
3 Pm	44.2
4 Pm	48.1
5 Pm	48.1
6 Pm	49.3
7 Pm	48.2
8 Pm	47.5
9 Pm	46.0

5.1.4.2 Season II

In second season, ambient noise monitoring was carried out at five locations and results are given in Table 5.12. Results are compared with Central Pollution Control Board Standards.

Table 5.12 Results of noise monitoring for season II

Sl No	Location Name	Area/Zone	CPCB Standards in dB(A)		Results in dB(A)	
			Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)
1	Bannihatti Transfer Point	Industrial Area	75	70	39.37	37.41
2	Road Intersect Point	Residential Area	55	45	34.72	34.53
3	1st Pillar Point	Silence Zone	50	40	50.39	44.02
4	Bhadra Hopper Point	Silence Zone	50	40	42.46	41.20
5	Bannihatti School	Silence Zone	50	40	29.12	37.92
Note: dB(A)- Decibel in scale A, Leq - Equivalent continuous sound level.						

Graphical representation of noise results for season II is given in Figure 5.13

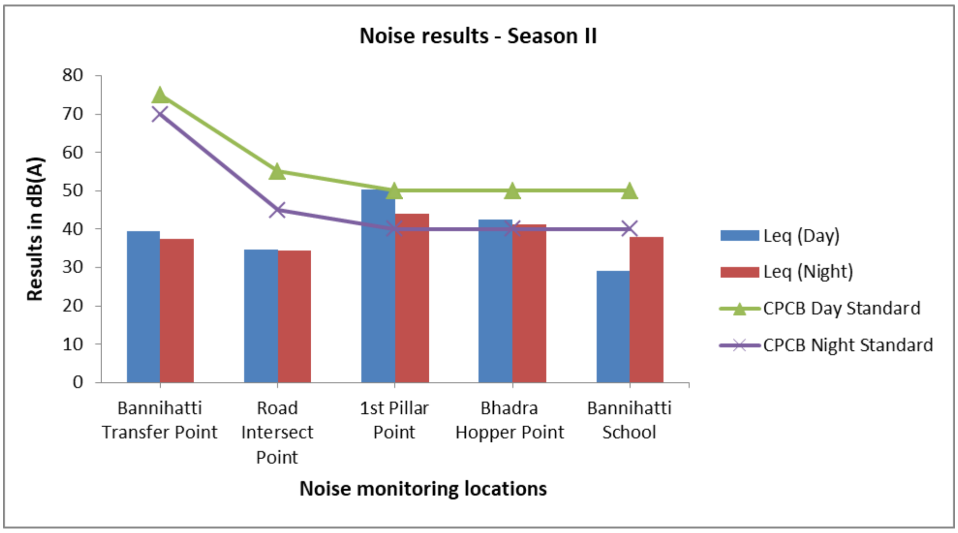


Figure 5.13 Graphical representation of Noise levels for season III

Tunga & Bhadra DHPC is one of the study area which is under construction phase. It comprises of industrial area, residential area and silence zone. Transfer point is the industrial area where the ore is transferred to the main pipe conveyor. In the industrial area, noise levels were recorded in one location, an average distance of 540 m from DHPC. Silence zones are Tunga & Bhadra hopper point, 1st pillar point and Bannihatti School present at the distance of 110 m, 700 m and 250 m respectively. At the distance of 200 m, road intersect point is considered as residential area.

In case of Bannihatti school the night time noise levels were 37.92 dB(A) is higher than the day time noise levels were 29.12 dB(A) in season II. This is due to trucks movement, train movement and use of loud speaker in nearby religious places during early morning (3 Am to 6 Am) and also natural sounds contributed to it.

The noise levels observed in all the area/zone were well within the CPCB Standards except 1st pillar point during day time were 50.39 dB(A), night time were 44.02 dB(A) and Bhadra hopper point during night time were 41.20 dB(A). The noise levels of 1st pillar point and Bhadra hopper point exceeded CPCB limits due to construction activities, vehicular movement particularly trucks carrying Iron ore, presence of crusher machine, driller machine, diesel generator and natural sounds contributed to increase in noise levels.

5.1.4.3 Season III

In third season, ambient noise monitoring was carried out at five locations and results are given in Table 5.13. Results are compared with Central Pollution Control Board Standards.

Table 5.13 Results of noise monitoring for season III

Sl No	Location Name	Area/Zone	CPCB Standards in dB(A)		Results in dB(A)	
			Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)
1	Bannihatti Transfer Point	Industrial Area	75	70	34.11	32.43
2	Road Intersect Point	Residential Area	55	45	44.18	39.47
3	1st Pillar Point	Silence Zone	50	40	26.14	25.42
4	Bhadra Hopper Point	Silence Zone	50	40	40.99	38.88
5	Bannihatti School	Silence Zone	50	40	37.04	42.04
Note: dB(A)- Decibel in scale A, Leq - Equivalent continuous sound level.						

Graphical representation of noise results for season III is given in Figure 5.14.

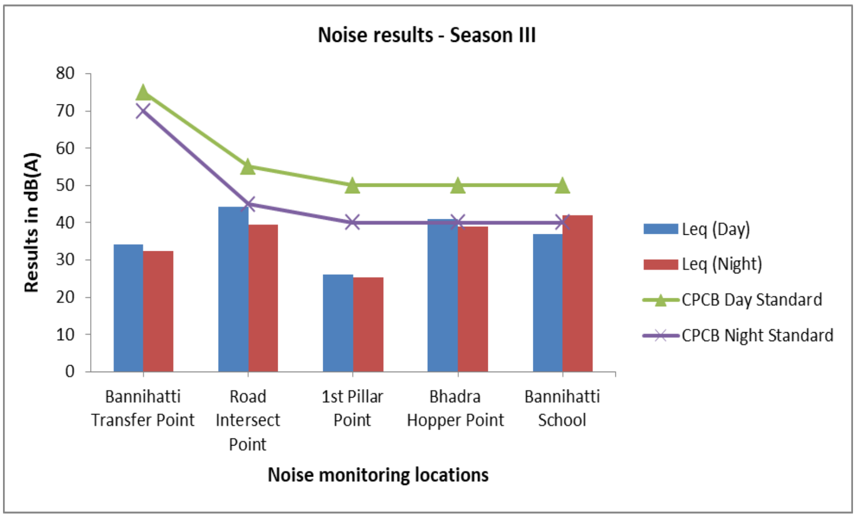


Figure 5.14 Graphical representation of noise results for season III

During season III, the noise levels observed in all the areas/zones were well within the CPCB Standards except Bannihatti school during night time were 42.04 dB(A) which is higher than the day time noise levels were 37.04 dB(A) due to trucks movement, train movement and use of loud speaker in nearby religious places during early morning (3 Am to 6 Am) and also natural sounds contributed to it.

5.1.4.4 Discussion

During season I, due to rain, noise monitoring was not carried out for 24 h whereas in season II and season III, 24 h monitoring was done and results were compared with CPCB Standards. Results revealed that monitored noise levels in all locations were within the CPCB Standards except 1st pillar point, Bhadra hopper point in season II and Bannihatti School in season III. This is due to construction activities, vehicular movement and natural sounds contributed to increase in noise levels in the study area.

5.1.5 ToR V – Soil quality

5.1.5.1 Season I

In first season, soil samples were collected from three locations viz., Bannihatti, Lingadahalli and Taranagar and the results are given in Table 5.14.

Table 5.14 Results of soil quality for season I

Sl No	Parameters	Units	Bannihatti	Lingadahalli	Taranagar
1	Bulk density	g/cm^3	1.4	1.5	1.37
2	Porosity	%	47.16	43.39	48.3
3	pH	--	8.67	7.43	9.69
4	Electrical Conductivity	µS/cm	353	4100	399
5	Calcium	ppm	90	76	188
6	Magnesium	mg/kg	28	19	62
7	Sodium	meq/100g	1.45	2.8	0.65
8	Potassium	ppm	2900	3800	1950
9	Chloride	meq/100g	0.4	12.2	0.4
10	Nitrate	ppm	12.57	12.20	4.95
11	Sulphate	mg/kg	28.10	53.65	40.51
12	Phosphate	mg/kg	102.87	88.92	27.87
13	Water Holding Capacity	%	56.7	46.7	60
14	Sodium Adsorption Ratio	%	0.26	0.57	0.08
15	Exchangeable Sodium Percentage	%	0.048	0.071	0.029
16	Sand	%	54.5	56.6	60.8
17	Silt	%	27.2	28.3	21.7

18	Clay	%	18.1	15	17.3
19	Organic Carbon	%	0.32	0.44	0.35
20	Organic Matter	%	0.55	0.76	0.61
Note: BDL - Below Detection Level, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, meq/100g - Milliequivalent per hundred gram, mg/kg - Milligram per kilogram, % - Percentage.					

pH in the study area ranged between 7.43 to 9.69. Highest pH was of 9.69 was recorded in Taranagar and overall soil pH in the study area was found to be alkaline. Graphical representation is given in Figure 5.15.

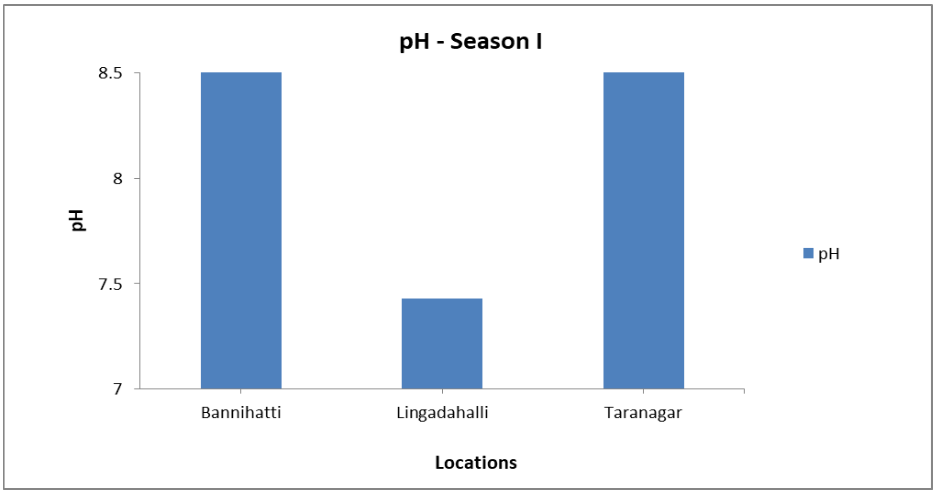


Figure 5.15 Graphical representation of pH in soil for season I

Electrical conductivity is the measure of amount of salts present in the soil. Electrical conductivity ranged from 353 to 4100 µS/cm with lowest value of 353µS/cm was observed in Bannihatti. Results showed sufficient amount of salts in the soil samples of the study area. Graphical representation is given in Figure 5.16.

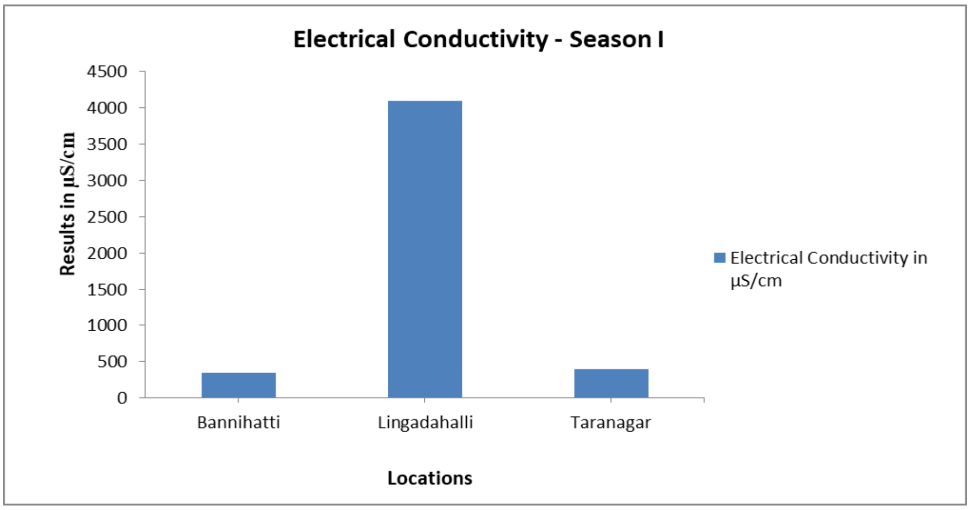


Figure 5.16 Graphical representation of Electrical Conductivity in soil for season I

Sand, silt and clay content in soil samples ranged from 54.5% to 60.8%, 21.7% to 28.3% and 15% to 18.1%. Hydrological Soil Group (HSG) classification revealed that the soil present in the study area is Silt or Loam (HSG - B) as shown in Table 5.15 and the classification is based on Table 4.19. Graphical representation is given in Figure 5.17.

Table 5.15 Sand, clay percentage and HSG classification

Sl No	Location	Sand (%)	Clay (%)	HSG
1	Bannihatti	54.5	18.1	Silt or Loam
2	Lingadahalli	56.6	15	Silt or Loam
3	Taranagar	60.8	17.3	Silt or Loam

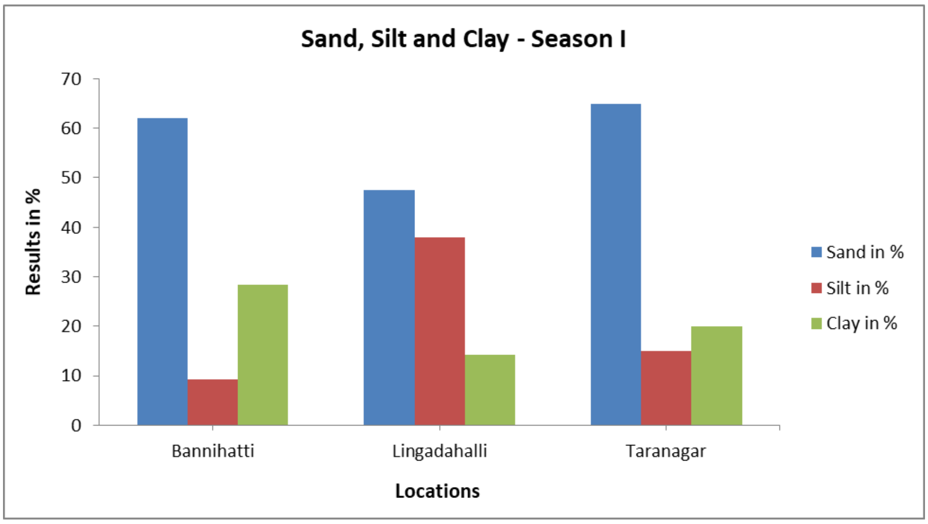


Figure 5.17 Graphical representation sand, silt and clay for season I

5.1.5.2 Season II

In second season, soil samples were collected from four locations namely Tunga & Bhadra Sponge Factory, Tunga & Bhadra Road Intersect, Bannihatti Transfer Point and Bannihatti School. Collected soil samples were analyzed for 20 parameters of which 17 parameters have been analyzed in EMPRI laboratory, Bengaluru while Phosphate, Nitrate and Sulphate were outsourced to Indian Institute of Horticultural Research (IIHR), Bengaluru. Results of season II is given in Table 5.16.

Table 5.16 Results of soil quality for season II

Sl No	Parameters	Units	TB Sponge Factory	TB Road Intersect	Bannihatti Transfer Point	Bannihatti School
1	Bulk density	g/cm^3	1.40	1.21	1.31	1.32
2	Porosity	%	47.03	54.19	50.47	50.18
3	pH	--	8.11	7.97	8.03	8.12
4	Electrical Conductivity	µS/cm	214	296	227	426
5	Calcium	ppm	185	160	135	300
6	Magnesium	mg/kg	76.08	253.92	107.13	56.79
7	Sodium	ppm	90	415	220	100
8	Potassium	meq/100g	221	162	192	215
9	Chloride	meq/100g	61	36	92	81
10	Nitrate	ppm	7.99	9.99	0.61	0.81
11	Sulphate	mg/kg	2.15	3.84	11.20	10.35
12	Phosphate	mg/kg	51.09	91.60	83.28	61.31
13	Water Holding Capacity	%	63.33	60	53.33	60
14	Sodium Adsorption Ratio	%	0.214	0.221	0.156	0.339
15	Exchangeable Sodium Percentage	%	0.28	0.35	0.21	0.44
16	Sand	%	26.92	22.72	22.62	27.48
17	Silt	%	53.84	63.60	43.14	40.35
18	Clay	%	19.23	22.72	34.24	31.90
19	Organic Carbon	%	0.47	1.32	2.16	0.37
20	Organic Matter	%	0.82	2.27	3.73	0.64

Note: BDL - Below Detection Level, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, meq/100g - Milliequivalent per hundred gram, mg/kg - Milligram per kilogram, % - Percentage.

pH in the study area ranged between 7.97 to 8.12. Highest pH was recorded at Bannihatti school (8.12) and overall soil pH in the study area was found to be alkaline. Graphical representation is given in Figure 5.18

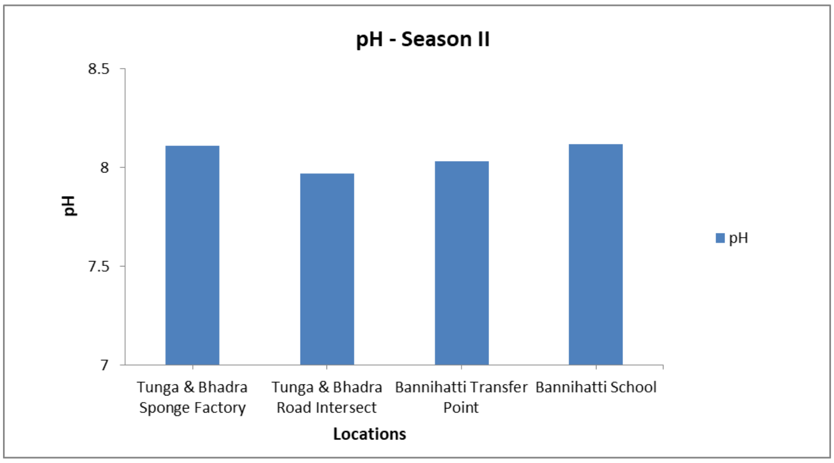


Figure 5.18 Graphical representation of pH in soil for season II

Electrical conductivity is the measure of amount of salts present in the soil. Electrical conductivity ranged from 214 to 426 µS/cm with highest observed in Bannihatti school (426 µS/cm). Results showed, sufficient amount of salts in the soil samples of the study area. Graphical representation is given in Figure 5.19

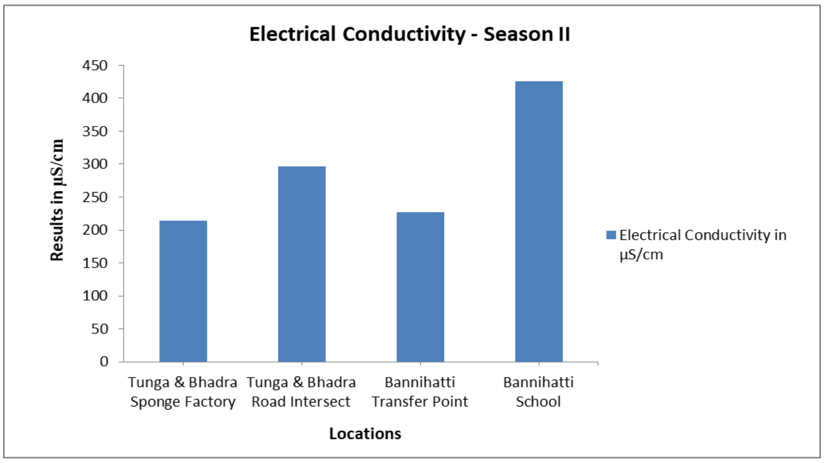


Figure 5.19 Graphical representation of Electrical Conductivity in soil for Season II

Sand, silt and clay content in soil samples ranged from 22.6% to 27.4%, 40.3% to 63.6% and 19.2% to 34.2%. Hydrological Soil Group (HSG) classification revealed that the soil present in the study area is Sandy Clay Loam (HSG - C) as shown in Table 5.17 and the classification was based on Table 4.19. Graphical representation is given in Figure 5.20.

Table 5.17 Sand, clay percentage and HSG classification

Sl No	Location	Sand (%)	Clay (%)	HSG
1	TB Sponge Factory	26.92	19.23	Sandy Clay Loam
2	TB Road Intersect	22.72	22.72	Sandy Clay Loam
3	Bannihatti Transfer Point	22.62	34.24	Sandy Clay Loam
4	Bannihatti School	27.48	31.9	Sandy Clay Loam

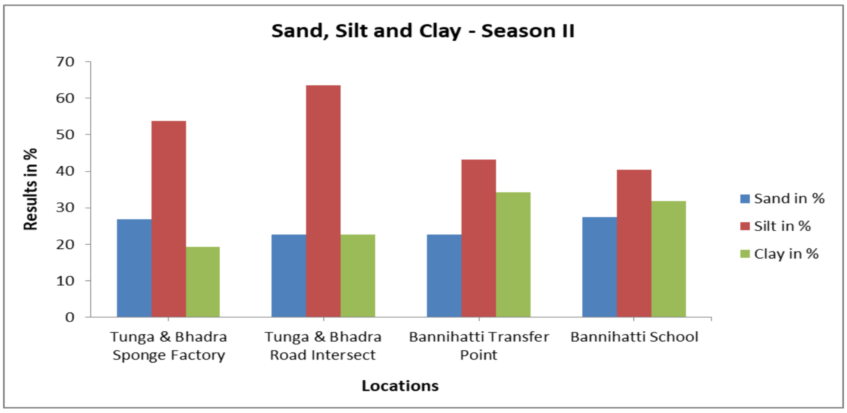


Figure 5.20 Graphical representation of sand, silt and clay for season II

5.1.5.3 Season III

In third season, soil samples were collected from four locations viz., Tunga & Bhadra Sponge Factory, Tunga & Bhadra Road Intersect, Bannihatti Transfer Point and Bannihatti School and results are given in Table 5.18

Table 5.18 Results of soil quality for season III

Sl No	Parameters	Units	TB Sponge Factory	TB Road Intersect	Bannihatti Transfer Point	Bannihatti School
1	Bulk density	g/cm^3	1.42	1.47	1.53	1.4
2	Porosity	%	46.4	44.5	42.3	47.2
3	pH	--	7.44	7.22	7.11	7.13
4	Electrical Conductivity	µS/cm	367	244	442	303
5	Calcium	meq/100g	145	30	180	155
6	Magnesium	meq/100g	120	25	95	35
7	Sodium	meq/100g	1.74	1.65	2.04	1.65
8	Potassium	ppm	1296	720	1064	1547
9	Chloride	meq/100g	0.4	0.5	BDL	BDL
10	Nitrate	mg/kg	8.25	16.62	7.56	10.69
11	Sulphate	mg/kg	29.2	166.11	9.57	60.32
12	Phosphate	mg/kg	12.89	37.69	50.33	44.38
13	Water Holding Capacity	%	62	59.2	52.8	58.8
14	Sodium Adsorption Ratio	--	0.2	0.4	0.2	0.2
15	Exchangeable Sodium Percentage	%	0.1	0.2	0.2	0.1
16	Sand	%	60.5	65.2	73.2	73.9
17	Silt	%	24.2	30.4	21.4	17.4
18	Clay	%	15.3	4.3	5.4	8.7
19	Organic Carbon	%	0.13	0.59	0.83	0.03
20	Organic Matter	%	0.24	1.02	1.44	0.06

Note: BDL - Below Detection Level, g/cm3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, meq/100g - Milliequivalent per hundred gram, mg/kg - Milligram per kilogram, % - Percentage.

pH in the study area ranged between 7.11 to 7.44. Highest pH was recorded at Tunga & Bhadra Sponge Factory (7.44) and overall soil pH in the study area was found to be near neutral to alkaline. Graphical representation is given in Figure 5.21.

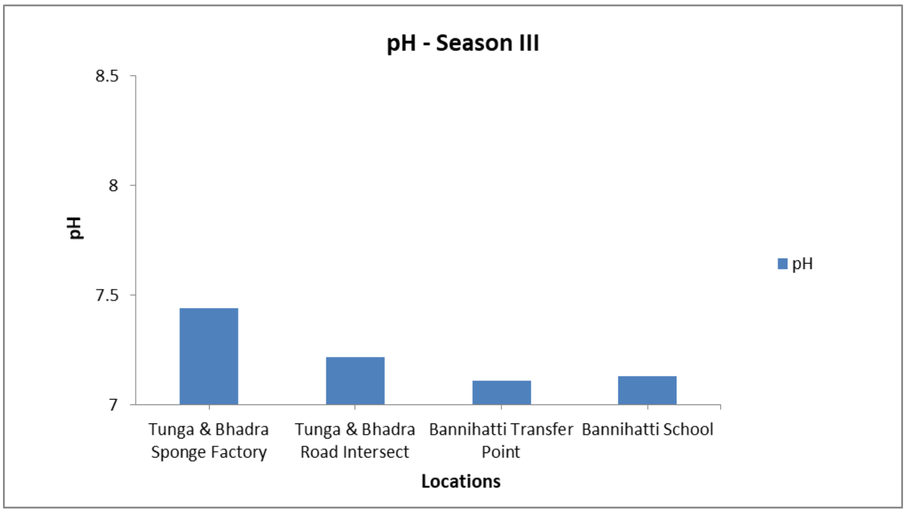


Figure 5.21 Graphical representation of pH in soil for season III

Electrical conductivity is the measure of amount of salts present in the soil. Electrical conductivity ranged from 244 to 442 µS/cm with highest observed in Bannihatti Transfer Point (442 µS/cm). Results showed sufficient amount of salts in the soil samples of the study area. Graphical representation is given in Figure 5.22.

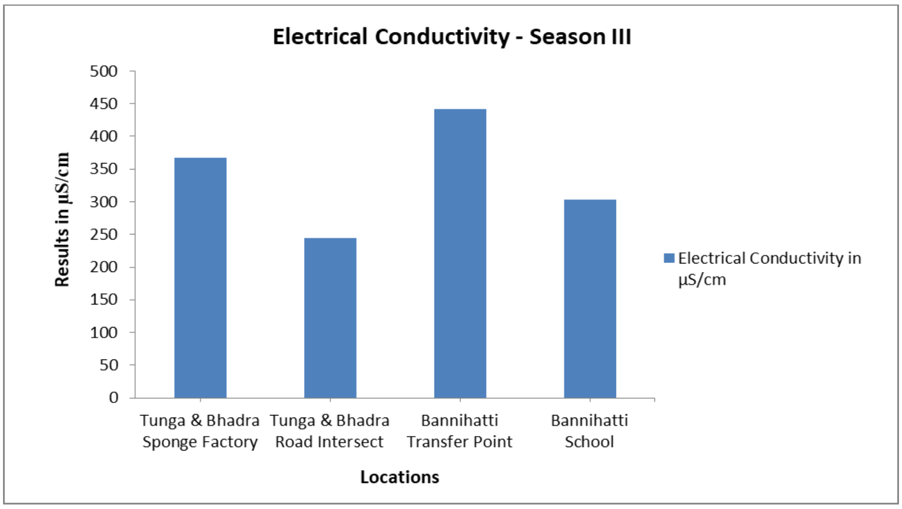


Figure 5.22 Graphical representation of Electrical Conductivity in soil for season III

Sand, silt and clay content in soil samples ranged from 57.1% to 76.2%, 13.90% to 32.40% and 4% to 15.30%. Hydrological Soil Group classification revealed that the soil present in the study area is Silt or Loam as shown in Table 5.19 and the classification was based on Table 4.19. Graphical representation is given in Figure 5.23.

Table 5.19 Sand, clay percentage and HSG classification

Sl No	Location	Sand (%)	Clay (%)	HSG
1	Tunga & Bhadra Sponge Factory	60.5	15.3	Silt or Loam
2	Tunga & Bhadra Road Intersect	65.2	4.3	Silt or Loam
3	Bannihatti Transfer Point	73.2	5.4	Silt or Loam
4	Bannihatti School	73.9	8.7	Silt or Loam

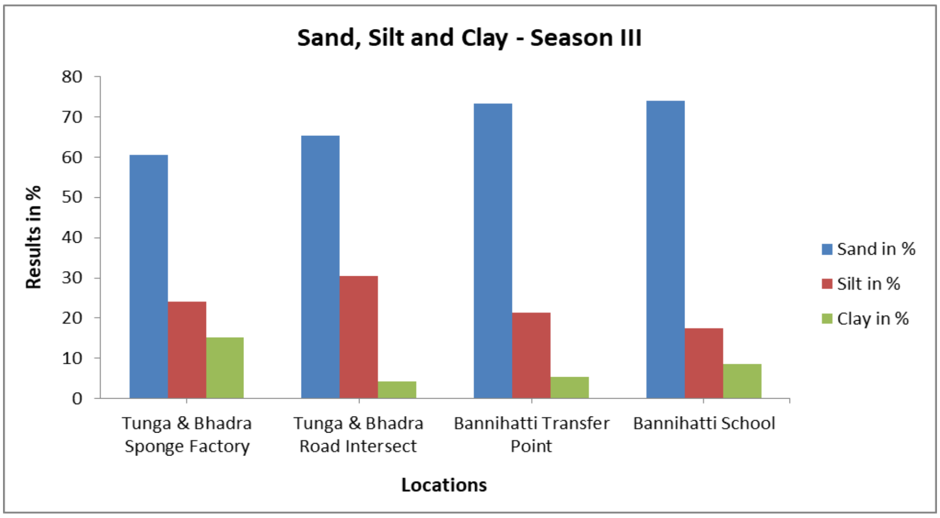


Figure 5.23 Graphical representation of sand, silt and clay for season III

5.1.5.4 Discussion

In all seasons the soil pH was found to be alkaline. Higher Electrical Conductivity was observed in all samples and seasons. Hydrological Soil Group classification revealed that in season I and season III, Silt or Loam whereas in season II, Sandy Clay Loam type of soil is present in the study area.

5.1.6 ToR VI – Meteorological monitoring

5.1.6.1 Season I

In first season, secondary data was collected from M/s JSW, Ballari and results are enclosed as Annexure IV.

5.1.6.2 Season II

In second season, secondary data was collected from M/s JSW, Ballari and results are enclosed as Annexure IV.

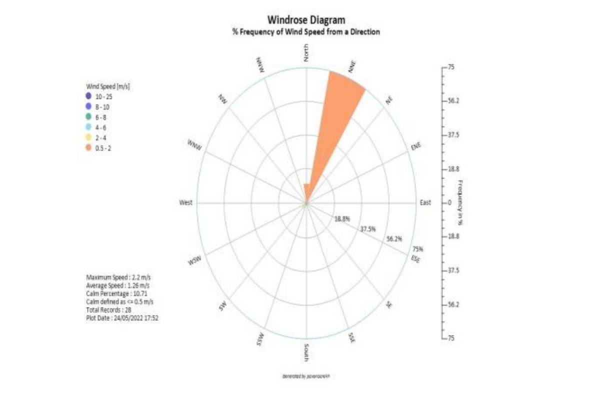
5.1.6.3 Season III

In third season, primary data related to temperature, rainfall, relative humidity, wind direction and wind speed was collected from meteorological station installed at M/s Tunga and Bhadra Iron ore mines and analyzed using a wind rose diagram drawn by Pavanaarekh software. Results are given in Table 5.20.

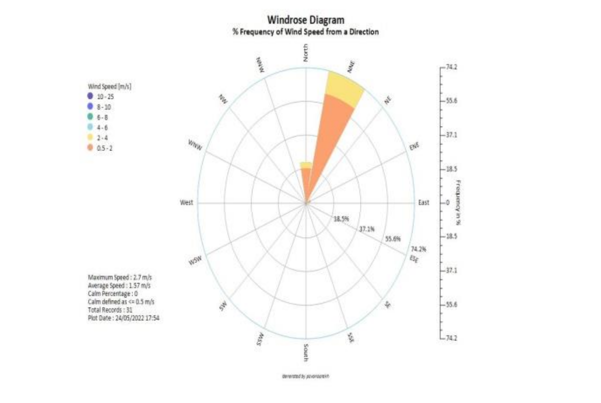
Table 5.20 Results of meteorological data for season III

Sl No	Month	Year		Temperature (°C)	Rainfall (mm)	Humidity (%)	Wind speed (m/s)	Dominant wind direction
1	February	2022	Max	32.4	0	100	2.2	North-North-East (NNE)
			Min	14.5	0	58.4	0.2	
			Avg	-	0	95.98	1.25	
2	March	2022	Max	35.7	0	100	2.7	North-North-East (NNE)
			Min	16.2	0	55.5	0.6	
			Avg	-	0	87.05	1.57	

The maximum temperature recorded in Tunga and Bhadra study area is 35.7ºC on 18.03.2022 and minimum temperature is 14.5 ºC on 04.02.2022 similarly 55.5% of minimum and 100% of maximum relative humidity was recorded on 12.03.2022 and 27.02.2022 respectively. Wind rose plot for Tunga and Bhadra DHPC is given in Figure 5.24 and predominant wind direction was found to be towards North-North-East during February and March 2022.



February-2022



March-2022

Figure 5.24 Windrose plot of Tunga and Bhadra DHPC for season III

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 Results

6.1.1 ToR I – Inventorisation of waterbodies

Through satellite imageries, the water bodies in the study area were delineated and further the same were verified through ground truth verification.

6.1.1.1 Season I

In the first season, 10 km area was considered for comprehensive study and the results are given in Table 6.1.

Table 6.1 List of waterbodies inventoried during season I

Sl No	Water body name	Distance (Km)	Remarks	GPS Coordinates	
				Latitude	Longitude
1	Devagolla Kere	1.80	Seasonal	15°11'1.662"N	76°32' 47.8752"E
2	Sushilnagar Nalla	7.34	Seasonal	15º6'35"N	76º30'49"E
3	Garaga Kere	5.52	Seasonal	15º 5' 59"N	76º 24' 27"E
4	Talur Kere	8.83	Seasonal	15°10'12.4284"N	76° 36' 44.28"E

Four surface water bodies were present in the Rama DHPC and all are seasonal.

6.1.1.2 Season II and Season III

In second and third season, only 1km area on either side of the DHPC was considered and the list of water bodies are given in Table 6.2.

Table 6.2 List of waterbodies inventoried during season II and III

Sl No	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

Four water bodies were found out of these Ramgad kunte and Kolifarm lake waterbodies are seasonal and Chinnapankola, Singanakere are perennial. Google imagery of the water body is given in Figure 6.1.

- **Singanakere** is a lake present in the premise of Doulatpura village of Ramanamalai block.
- The lake is spread across the area of 5.396 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.

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

6.1.2 ToR II - Surface water and Groundwater

6.1.2.1 Season I (Surface water)

During first season only Narihalla surface water was considered since it is perennial and the results are given in Table 4.3.

6.1.2.2 Season II

During second season, 2 km area on either side of the DHPC was considered for the study and four surface water samples were collected and analysed. The results are given in Table 6.3.

Table 6.3 Results of surface water quality during season II

Sl No	Parameters	Water Quality Criteria					Ramgad kunte	Chinnapa nkola	Singana kere	Koliform lake
		A	B	C	D	E				
1	pH	6.5 – 8.5				6 – 8.5	7.6	7.2	7.3	7.1
2	Odour	-	-	-	-	-	Odourless			
3	Colour (Hazen)	-	10	300	300	-	9	5	1	7
4	Total Dissolved Solids (mg/L)	500	-	1500	-	2100	139.4	555.6	506	537.4
5	Chloride (mg/L)	250	-	600	-	600	34.9	85.3	93.3	47.6
6	Sulphate (mg/L)	400	-	400	-	1000	34.98	94.97	99.96	59.96
7	Fluoride (mg/L)	1.5	1.5	1.5	-	-	BDL	BDL	BDL	BDL
8	Boron (mg/L)	-	-	-	-	-	0.28	0.36	0.38	0.32
9	Sodium (mg/L)	-	-	-	-	-	29	85	73	103
10	Iron (mg/L)	0.3	-	-	0.5	-	0.14	1.54	0.98	1.42
11	Oil & Grease (mg/L)	-	-	-	-	-	Below Detection Level			
12	Total Suspended Solid (mg/L)	-	-	-	-	-	2	42.2	24.2	17.6
13	Total Volatile Solid (mg/L)	-	-	-	-	-	92.2	130.4	221.6	135.2
14	Chemical Oxygen Demand (mg/L)	-	-	-	-	-	32	32	36	36
15	Biochemical Oxygen Demand (mg/L)	2	3	3	-	-	5.48	BDL	BDL	3.65
16	Sulphide (mg/L)	-	-	-	-	-	0.002	0.008	0.004	0.003
17	Residual Sodium Carbonate (mg/L)	-	-	-	-	-	BDL	BDL	3.438	5.148
18	Phosphate (mg/L)	-	-	-	-	-	0.804	0.081	0.023	0.035
19	Total Coliform (MPN/100ml)	50	500	5000	-	-	1600	920	49	130

Sl No	Parameters	Water Quality Criteria					Ramgad kunte	Chinnapa nkola	Singana kere	Koliform lake
		A	B	C	D	E				
20	Faecal Coliform (MPN/100ml)	-	-	-	-	-	1600	540	33	49
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										

Results were compared with designated best use water quality standards given by CPCB and majority locations come under designated best use ‘C’ i.e., drinking water source after conventional treatment and disinfection.

6.1.2.3 Season III

In the third season, surface water samples were collected from only two water bodies as the other two are seasonal and dried during the period of sampling. Results are given in the Table 6.4.

Table 6.4 Results of surface water during season III

Sl No	Parameters	Water Quality Criteria					Singanakere	Koliform
		A	B	C	D	E		
1	pH	6.5 – 8.5				6 – 8.5	7.3	7.5
2	Odour	-	-	-	-	-	Odourless	
3	Colour (Hazen)	-	10	300	300	-	1	5
4	Total Dissolved Solids (mg/L)	500	-	1500	-	2100	499.4	663.2
5	Chloride (mg/L)	250	-	600	-	600	109.9	64.9
6	Sulphate (mg/L)	400	-	400	-	1000	26.61	27.03
7	Fluoride (mg/L)	-	-	-	-	-	0.26	0.42
8	Boron (mg/L)	-	-	-	-	<2	0.1	0.2
9	Sodium (mg/L)	-	-		-	-	97	73
10	Iron (mg/L)	-	-	-	-	-	0.87	1.5
11	Oil & Grease (mg/L)	-	-	-	-	-	0.8	BDL
12	Total Suspended Solid (mg/L)	-	-	-	-	-	23.2	19.6
13	Total Volatile Solid (mg/L)	-	-	-	-	-	145.4	183.2
14	Chemical Oxygen Demand (mg/L)	-	-	-	-	-	12.3	46.2
15	Biochemical Oxygen Demand (mg/L)	≤2	≤3	≤3	-	-	BDL	8.2
16	Sulphide (mg/L)	-	-	-	-	-	BDL	BDL

Sl No	Parameters	Water Quality Criteria					Singanakere	Koliform
		A	B	C	D	E		
17	Residual Sodium Carbonate (mg/L)	-	-	-	-	-	BDL	2.47
18	Phosphate (mg/L)	-	-	-	-	-	BDL	BDL
19	Total Coliform (MPN/100ml)	≤50	≤500	≤500	-	-	280	33
20	Faecal Coliform (MPN/100ml)	-	-	-	-	-	130	23

6.1.2.4 Discussion

Water sample location has changed from first season to second and third and a comparative study of water quality has been done only between Singanakere and Koliform, as these two are the perennial water bodies of this study area. Collected samples were analysed for 20 parameters as per ToRs accorded. The results were compared with, designated best use water quality standards given by CPCB. In all the samples COD is greater than BOD hence, the COD:BOD ratio is also balanced. The presence of total coliform and faecal coliform is identified in all the water bodies which might be due to open defecation in the region.

Singanakere falls under designated best use category 'B'- Outdoor bathing (Organised) while Kolifarm lake comes under designated best use 'C' i.e., Drinking water source after conventional treatment and disinfection.

6.1.2.5 Season I (Groundwater)

During first season, three groundwater samples were collected and analysed, and the results of the same are given in Table 6.5.

Table 6.5 Results of groundwater quality for season I

Sl No	Parameters	Units	Std. IS 10500:2012*		Ramgad	Siddapura	Sushilnagar
			AL*	PL*			
1	pH at 25°C	-	6.5 – 8.5	NR	7.3	7.5	7.5
2	Colour	Hazen	5	15	1	1	1
3	Odour		Agreeable		Odourless		
4	Total Dissolved Solids	mg/L	500	2000	522	812	969
5	Turbidity	NTU	1	5	0.3	0.8	0.6
6	Chloride	mg/L	250	1000	77.4	104.9	229.9
7	Total hardness	mg/L	200	600	360	585	585
8	Calcium as Ca	mg/L	75	200	90.1	128.2	146.2
9	Magnesium as Mg	mg/L	30	100	32.8	64.3	53.4
10	Alkalinity as $CaCO_3$	mg/L	200	600	320	470	370
11	Sulphate as SO_4	mg/L	200	400	5.33	22.2	57.8
12	Fluoride as F	mg/L	1	1.5	1.03	BDL	BDL
13	Boron as B	mg/L	0.5	1	BDL	BDL	BDL
14	Sodium as Na	mg/L	--		51	62	70
15	Potassium as K	mg/L	--		0.4	0.4	1.6
16	Total Chromium	mg/L	0.05	NR	0.017	0.01	0.028
17	Copper (Cu)	mg/L	0.05	1.5	BDL	BDL	BDL
18	Iron(Fe)	mg/L	0.3	NR	0.3892	0.245	0.2224
19	Lead (Pb)	mg/L	0.01	NR	BDL	BDL	BDL
20	Manganese (Mn)	mg/L	0.1	0.3	BDL	BDL	BDL
21	Zinc (Zn)	mg/L	5	15	0.103	BDL	1.5373
22	Cadmium (Cd)	mg/L	0.003	NR	0.0255	0.037	0.0421
23	Nitrate	mg/L	45	NR	23.12	16.12	20.32
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	BDL	0.543	0.012
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL
27	T. Arsenic	mg/L	0.01	0.05	BDL	BDL	BDL
28	Total Coliform	MPN/ 100mL	Nil	6.8	170	4.5	130

* AL- Acceptance Limit, PL- Permissible Limit, OL- Odourless, BDL- Below Detection Limit, NR- No Relaxation, S- Season

Graphical representation of the Total hardness, Calcium and Magnesium is given in Figure 6.2

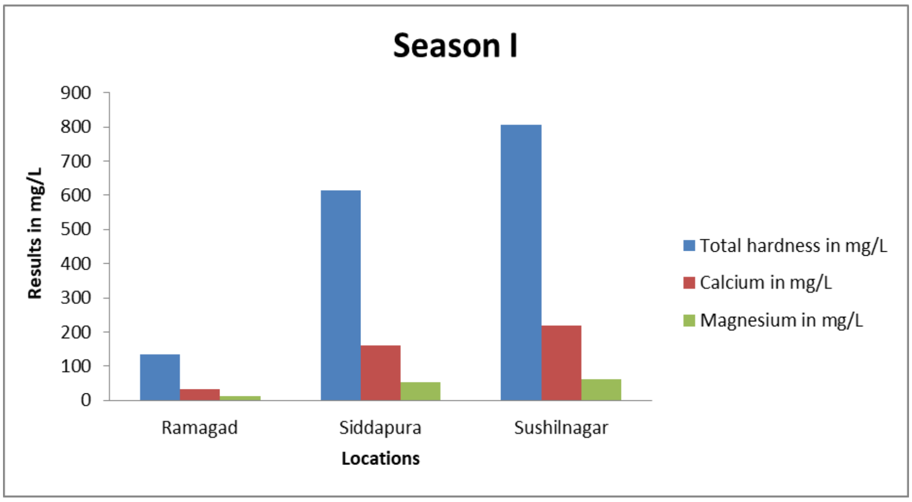


Figure 6.2 Graphical representation of TH, Ca and Mg for season I

The Ground Water Quality Index (GWQI) during season II in three locations is unsuitable - E grade. This is majorly because of Iron, Aluminium and Cadmium concentrations are exceeding the permissible limit. Graphical representation of the same is given in Figure 6.3.

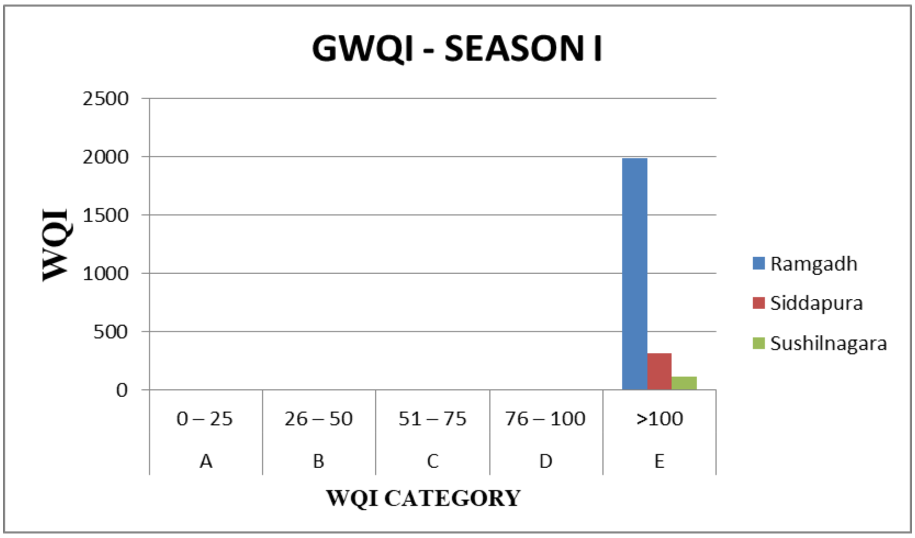


Figure 6.3 Graphical representation of GWQI for season I

6.1.2.6 Season II

During second season, four groundwater samples were collected and analysed, and the results of the same are given in Table 6.6.

Table 6.6 Results of groundwater quality in season II

Sl No	Particular	Units	Std. IS 10500:2012*		Ramgad-Tayamma temple	Radhanagar	Sushilnagar school	Doulatpura
			AL*	PL*				
1	pH	--	6.5 - 8.5	NR		6.5	6.5	6.6
2	Odour		Agreeable		Odourless			
3	Colour	Hazen	5	15	1	2	2	1
4	Total Dissolved Solids	mg/L	500	2000	248.4	755	1656.2	949.4
5	Chlorides	mg/L	250	1000	129	108.1	228.7	194.9
6	Sulphate	mg/L	200	400	21.2	31.1	118.66	62.3
7	Fluoride	mg/L	1	1.5	Below Detection Level			
8	Boron	mg/L	0.5	1	0.16	0.3	3.92	0.33
9	Calcium	mg/L	75	200	52.1	132.2	220.4	120.2
10	Sodium	mg/L	--		32	91	100	101
11	Iron	mg/L	0.3	NR	1.1	0.18	0.48	0.18
12	Turbidity	mg/L	1	5	1.18	0.23	0.08	0.26
13	Total Hardness	mg/L	200	600	150	570	1150	660
14	Magnesium	mg/L	30	100	4.86	58.3	145.8	87.4
15	Nitrate	mg/L	45	NR	BDL	BDL	0.407	BDL
16	Total Alkalinity	mg/L	200	600	118	470	432	320
17	Potassium	mg/L	--		10	3	8	1
18	Copper	mg/L	0.05	1.5	BDL	BDL	BDL	BDL
19	Manganese	mg/L	0.1	0.3	2.85	0.09	0.02	0.03
20	Zinc	mg/L	5	15	BDL	0.24	BDL	BDL
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL	BDL
22	Lead	mg/L	0.01	NR	BDL	0.06	0.09	0.05
23	Total Chromium	mg/L	0.05	NR	BDL	BDL	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	0.008	BDL
25	Aluminium	mg/L	0.003	NR	0.484	0.071	0.061	0.022
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	0.009	0.001	0.048	0.002
28	Total Coliform	MPN/ 100mL	Nil		6.8	170	4.5	130

* AL- Acceptance Limit, PL- Permissible Limit, OL- Odourless, BDL- Below Detection Limit, NR- No Relaxation, S- Season

Graphical representation of the Total hardness, Calcium and Magnesium is given in Figure 6.4 to show the balanced ration (TH ≥ Ca + Mg).

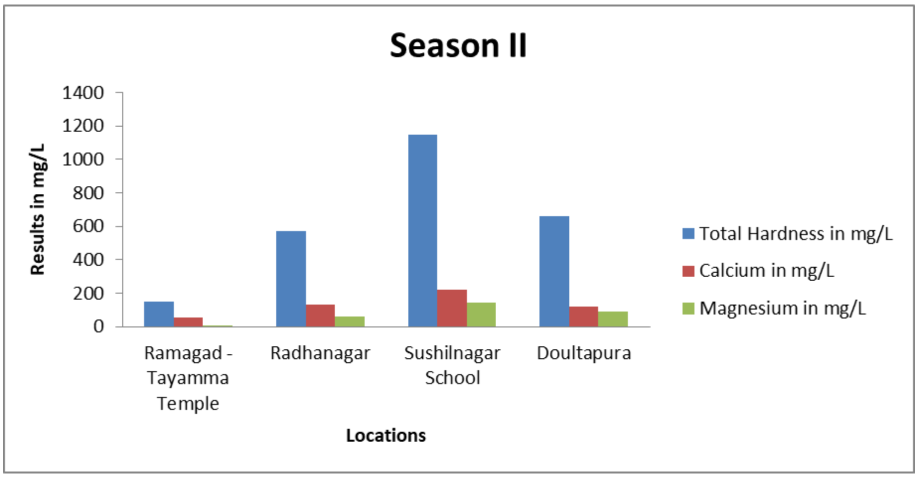


Figure 6.4 Graphical representation of TH, Ca and Ma in season II

The GWQI during season II ranged between poor - C to unsuitable - E category. This is majorly because of total hardness along with Iron, Aluminium, Manganese, Lead, Boron and Total Arsenic concentration which was found in excess than the permissible limit. Graphical representation of the same is given in Figure 6.5.

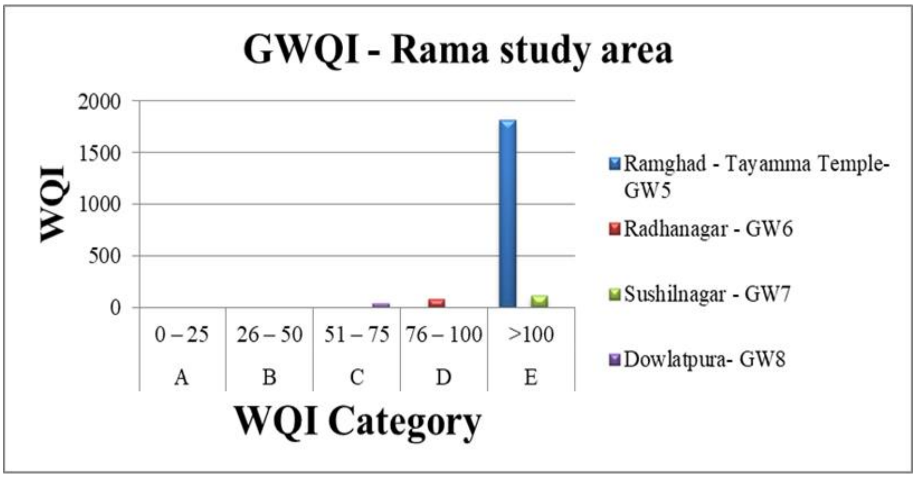


Figure 6.5 Graphical representation of GWQI for season II

6.1.2.7 Season III

During third season, four groundwater samples were collected and analysed, and the results of the same are given in Table 6.7.

Table 6.7 Results of groundwater quality in season III

Sl No	Particular	Units	Std. IS 10500:2012*		Ramgad-Tayamma temple	Radhanagar	Sushilnagar school	Doulatpura
			AL*	PL*				
1	pH	--	6.5 - 8.5	NR	7.3	7.4	7.2	7.4
2	Odour		Agreeable		Odourless			
3	Colour	Hazen	5	15	1	1	1	1
4	Total Dissolved Solids	mg/L	500	2000	318.4	882.2	1777	617.4
5	Chlorides	mg/L	250	1000	19.9	144.9	384.8	79.9
6	Sulphate	mg/L	200	400	8.8	45.7	99	24.7
7	Fluoride	mg/L	1	1.5	0.13	0.47	0.42	0.64
8	Boron	mg/L	0.5	1	0.03	0.08	0.17	0.129
9	Calcium	mg/L	75	200	70.7	200.3	353.5	172.8
10	Sodium	mg/L	--		52	130	220	63
11	Iron	mg/L	0.3	NR	1.63	0.08	0.14	0.16
12	Turbidity	mg/L	1	5	1.72	0.2	0.33	0.35
13	Total Hardness	mg/L	200	600	278.1	679.8	1318.4	556.2
14	Magnesium	mg/L	30	100	24.7	43.7	106	30.4
15	Nitrate	mg/L	45	NR	0.7	9.7	10.1	7.3
16	Total Alkalinity	mg/L	200	600	176	480	256	284
17	Potassium	mg/L	--		59.2	18.8	41.2	2.8
18	Copper	mg/L	0.05	1.5	BDL	0.05	0.05	0.05
19	Manganese	mg/L	0.1	0.3	2.61	BDL	BDL	BDL
20	Zinc	mg/L	5	15	BDL	BDL	BDL	BDL
21	Cadmium	mg/L	0.003	NR	BDL	BDL	BDL	BDL
22	Lead	mg/L	0.01	NR	0.05	0.06	BDL	0.1
23	Total Chromium	mg/L	0.05	NR	BDL	BDL	BDL	BDL
24	Mercury	mg/L	0.001	NR	BDL	BDL	BDL	BDL
25	Aluminium	mg/L	0.003	NR	0.224	0.234	0.233	0.396
26	Cyanide	mg/L	0.05	NR	BDL	BDL	BDL	BDL
27	Total Arsenic	mg/L	0.01	0.05	BDL	0.002	0.007	BDL
28	Total Coliform	MPN/ 100mL	Nil		<1.8	<1.8	<1.8	130

* AL- Acceptance Limit, PL- Permissible Limit, OL- Odourless, BDL- Below Detection Limit, NR- No Relaxation, S- Season

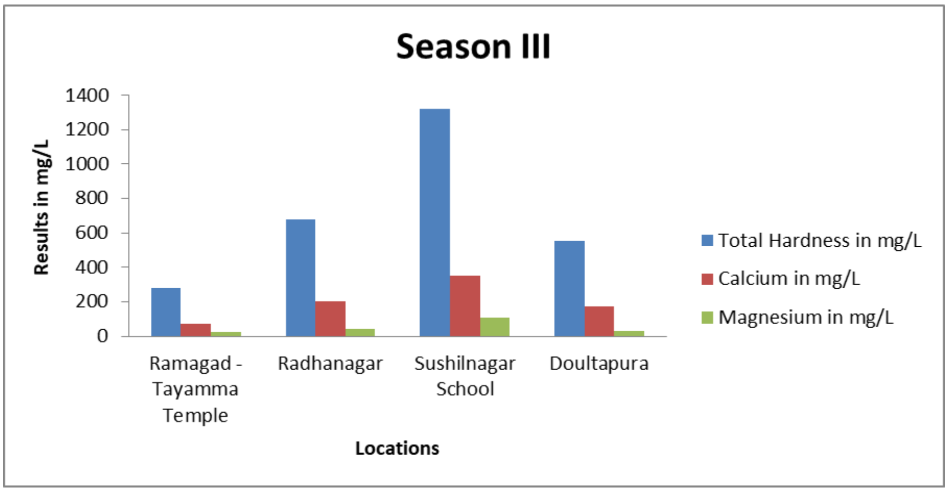


Figure 6.6 Graphical representation of TH, Ca and Mg in mg/L

The Ground Water Quality Index (GWQI) during season II ranged between excellent - A to unsuitable – E category. This is majorly because of total hardness along with Iron, Aluminium, Manganese and Lead concentration which was found exceeding the permissible limit. Graphical representation of the same is given in Figure 6.7.

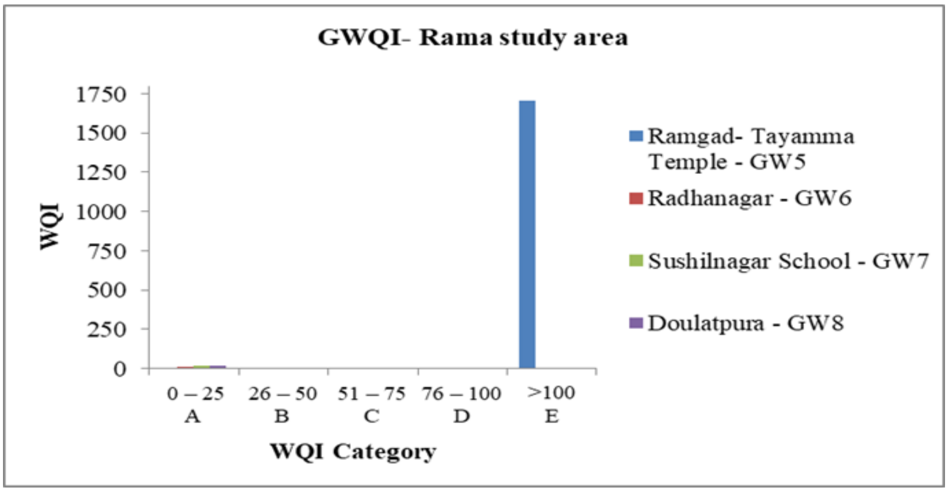


Figure 6.7 Graphical representation of GWQI for season III

6.1.2.8 Discussions

In all of the three seasons, higher level of hardness is observed which does not cause health effects on humans but results in scale formation. Fluoride content was found to be below acceptable limit in all samples and seasons. Heavy metals like Iron, Aluminium, Manganese, Lead, Boron and Total Arsenic concentration was found exceeding the permissible limit. In season I, II and III the GWQI ranged from E, C-E and A-E respectively.

6.1.3 ToR III – Ambient Air

6.1.3.1 Season I

During first season, air monitoring was not conducted in the study area.

6.1.3.2 Season II

During second season, air monitoring was conducted in 4 locations. The results are given in Table 6.8 and the obtained results were compared with National Ambient Air Quality Standards.

Table 6.8 Results of air quality for season II

Sl No	Locations	Units	PM_{10}	$PM_{2.5}$	SO_2	NO_2
	NAAQ Standards	**$\mu g/m^3$**	**100**	**60**	**80**	**80**
1	Rama Hopper Point	$\mu g/m^3$	170.48	23.84	101.53	2.52
2	Ramgad Village	$\mu g/m^3$	146.29	33.12	144.09	3.61
3	Transfer Point 1 (Sushilnagar)	$\mu g/m^3$	211.41	83.75	256.95	2.41
4	Transfer Point 2 (Doulatpura)	$\mu g/m^3$	232.38	59.52	239.06	4.84
5	Sushilnagar School	$\mu g/m^3$	221.82	56.17	150.8	2.87

Graphical representation of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 for season II is given in Figure 6.8, 6.9 and 6.10 respectively.

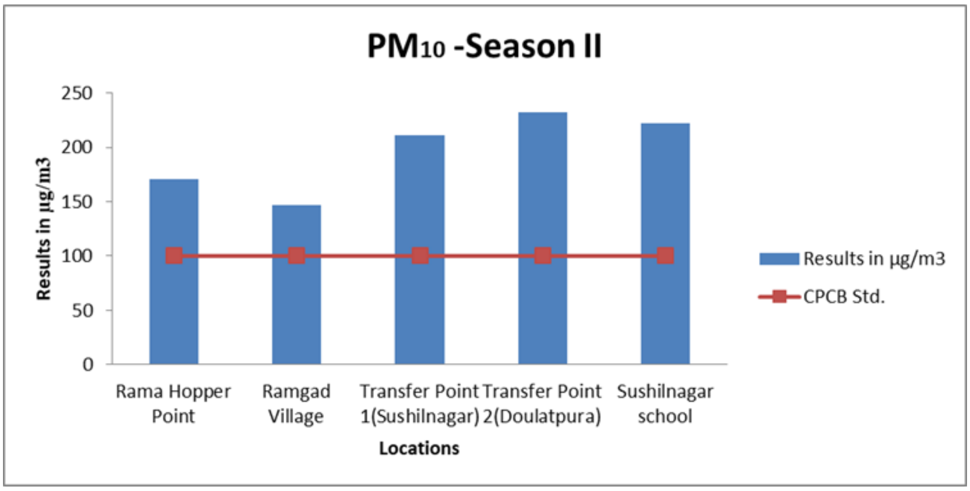


Figure 6.8 Graphical representation of PM_{10} for season II

During season II, PM_{10} concentrations exceeded the National Ambient Air Quality Standards in all five locations which may be due to vehicular movement and in turn, increased the dust level and resulted in spike of Particulate Matter – 10 concentrations.

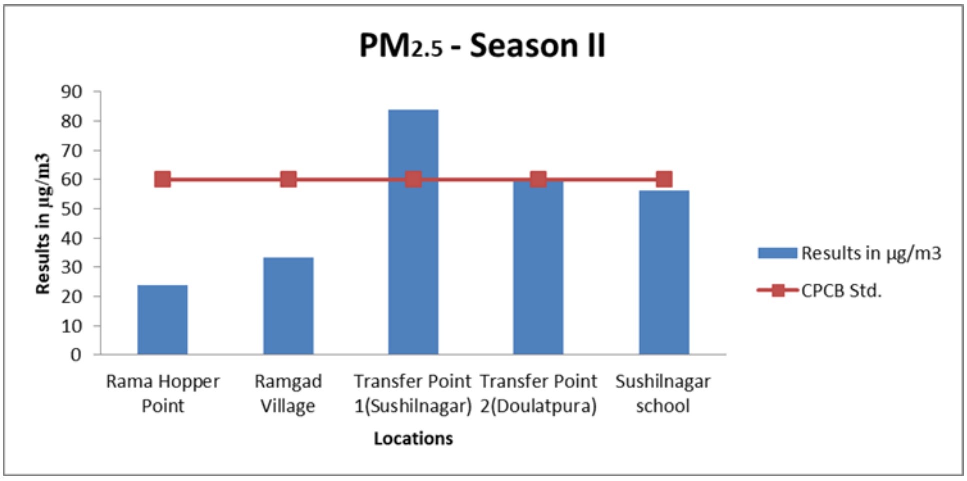


Figure 6.9 Graphical representation of $PM_{2.5}$ for season II

During season II, Particulate Matter – 2.5 ($PM_{2.5}$) concentrations exceeded the National Ambient Air Quality Standards in transfer point 1, which may be due to dust raised from transportation of Iron ore through trucks and mining activities (loading, unloading, crushing, drilling, blasting etc) in the study area.

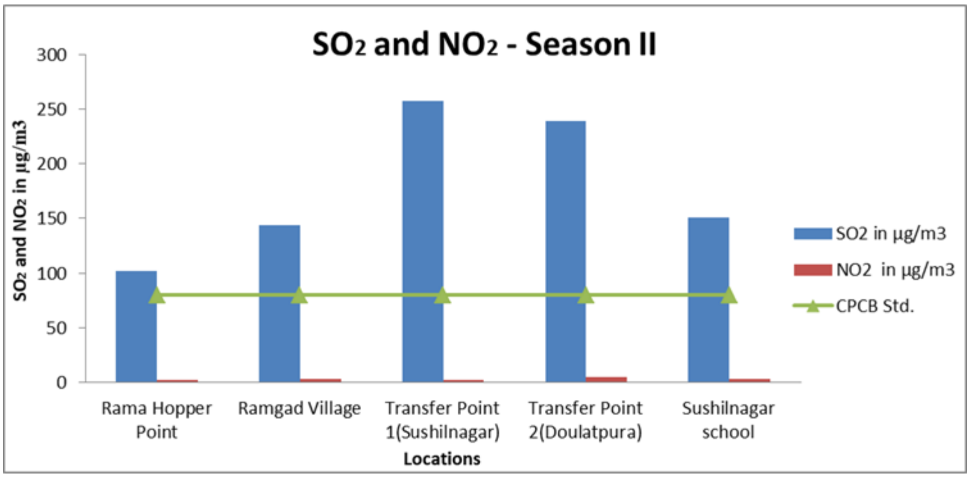


Figure 6.10 Graphical representation of SO_2 and NO_2 for season II

During season II, SO_2 concentration exceeded the National Ambient Air Quality Standards in all the five locations monitored. NO_2 concentration in all five locations was found to be well within the National Ambient Air Quality Standards.

Table 6.9 AQI for season II

Sl No	Location Name	Air Quality Index	Category
1	Rama Hopper Point	147	Moderate
2	Ramgad Village	131	Moderate
3	Transfer Point 1 (Sushilnagar)	179	Moderate
4	Transfer Point 2 (Doulatpura)	188	Moderate
5	Sushilnagar School	181	Moderate

During second season, Air Quality Index (AQI) of five locations was calculated using Central Pollution Control Board (CPCB) AQI calculator. Results revealed that in season II and tabulated in the Table 6.9, AQI was moderate in the study area.

6.1.3.3 Season III

During third season, air monitoring was conducted in 4 locations. The results are given in Table 6.10 and the obtained results were compared with National Ambient Air Quality standards.

Table 6.10 Results of air quality for season III

Sl No	Locations	Units	PM_{10}	$PM_{2.5}$	SO_2	NO_2
	NAAQ Standards	**$\mu g/m^3$**	**100**	**60**	**80**	**80**
1	Rama Hopper Point	$\mu g/m^3$	516.77	44.70	2.49	31.05
2	Ramgad Village	$\mu g/m^3$	395.53	42.77	2.94	35.59
3	Transfer Point 1 (Sushilnagar)	$\mu g/m^3$	327.31	83.23	1.10	38.74
4	Transfer Point 2 (Doulatpura)	$\mu g/m^3$	310.87	67.98	6.90	29.56
5	Sushilnagar School	$\mu g/m^3$	469.72	84.59	1.96	15.17

Graphical representation of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 for season II is given in Figure 6.11, 6.12 and 6.13 respectively.

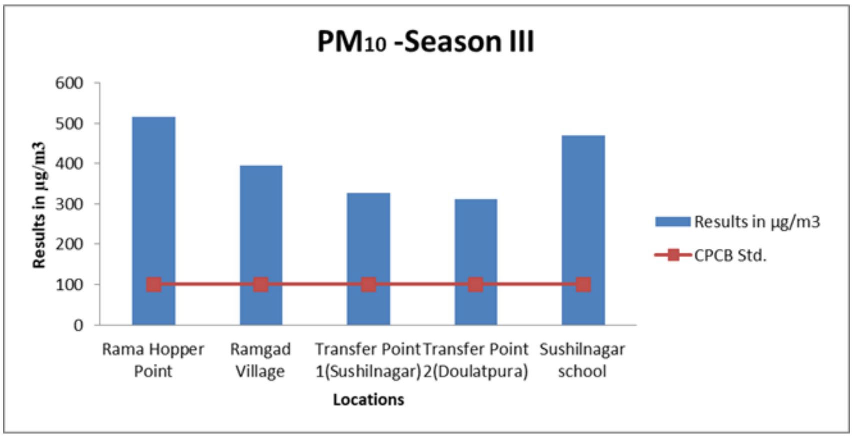


Figure 6.11 Graphical representation of PM10 for season III

During season III, Particulate Matter – 10 (PM_{10}) concentrations exceeded the National Ambient Air Quality Standards in all five locations which may be due to vehicular movement which in turn increased the dust level and resulted in spike of Particulate Matter – 10 concentrations.

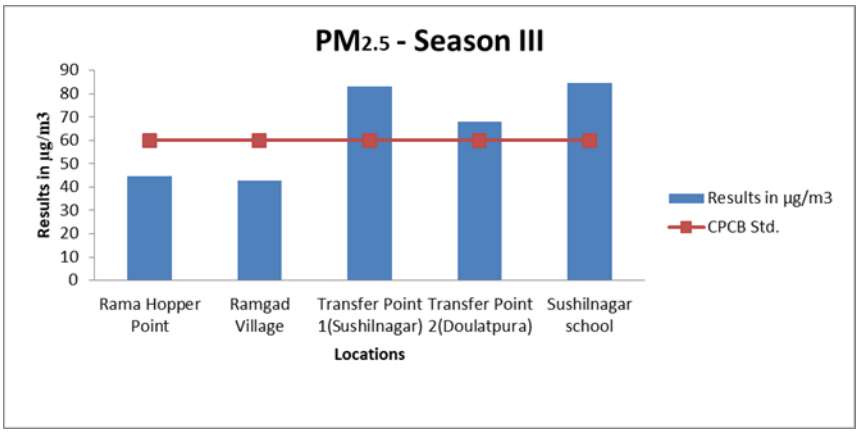


Figure 6.12 Graphical representation of $PM_{2.5}$ for season III

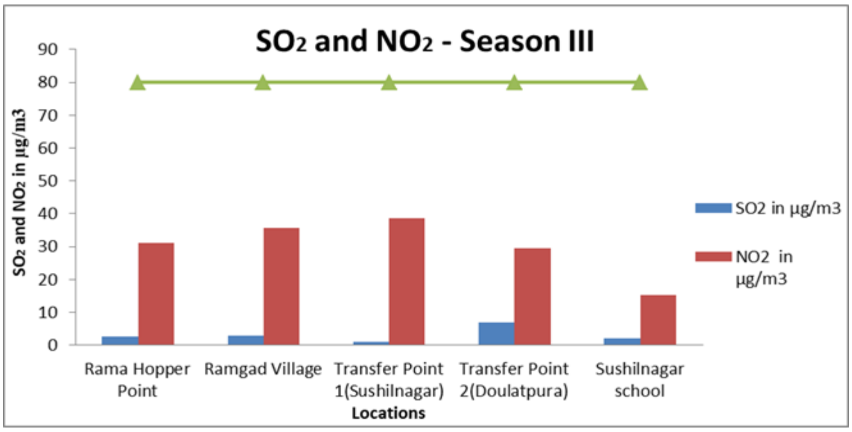


Figure 6.13 Graphical representation of SO_2 and NO_2 for season III

During season III, Particulate Matter – 2.5 ($PM_{2.5}$) concentrations exceeded the National Ambient Air Quality Standards in transfer point 1 which may be due to vehicular activities in the study area. During season III, SO_2 concentration exceeded the National Ambient Air Quality Standards in all the five locations monitored. NO_2 concentration in all five locations was found to be well within the National Ambient Air Quality Standards.

Table 6.11 Air Quality Index for season III

Sl No	Location Name	AQI	Category
1	Rama Hopper Point	508	Severe
2	Ramgad Village	357	Very Poor
3	Transfer Point 1 (Sushilnagar)	277	Poor
4	Transfer Point 2 (Doulatpura)	261	Poor
5	Sushilnagar School	450	Severe

During third season, Air Quality Index (AQI) of five locations was calculated using Central Pollution Control Board (CPCB) AQI calculator. Results revealed that in season III, air quality index in the study area varied from poor to severe. During third season, AQI of five locations was calculated using CPCB AQI calculator. Results revealed that in season III, AQI falls under poor to severe category in the study area as shown in Table 6.11.

6.1.3.4 Discussion

Due to rain, air monitoring could not be carried in season I for 24 h, but in season II and III monitoring was done for 24 h and results were compared with National Ambient Air Quality Standards a comparison between both seasons reveals that concentration of Particulate Matter – 10 (PM_{10}) in all five locations was above National Ambient Air Quality Standards. Particulate Matter – 2.5 ($PM_{2.5}$) concentration in Transfer point 1 (Sushilnagar) was found to be high compared to NAAQ Standards in both the seasons. SO_2 concentration is above National Ambient Air Quality Standards in all the locations and seasons. NO_2 concentration in all five locations was well within the National Ambient Air Quality Standards.

6.1.4 ToR IV – Noise monitoring

6.1.4.1 Season I

During first season noise monitoring was conducted in one location i.e., Sushilnagar school. The results are given in Table 6.12 and are not compared to CPCB Standards since 24 h monitoring was not conducted due to rain.

Table 6.12 Results of noise monitoring for season I

Time	Results in dB(A)
6 Am	50.13
7 Am	56.29
8 Am	53.83
10 Am	49.43
11 Am	49.32
12 Pm	47.97
1 Pm	46.29

6.1.4.2 Season II

During second season noise monitoring was conducted in four locations. The results are given in Table 6.13.

Table 6.13 Results of noise monitoring for season II

Sl No	Locations	Zone	CPCB Standards in dB(A)		Results in dB(A)	
			Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)
1	Rama Hopper point	Silence Zone	50	40	39.12	37.92
2	Ramgad Village	Silence Zone	50	40	42.46	41.20
3	Transfer Point 1 (Sushilnagar)	Silence Zone	50	40	33.14	33.97
4	Transfer Point 2 (Doulatpura)	Residential Area	55	45	35.35	32.57
5	Sushilnagar School	Silence Zone	50	40	31.49	31.61

Graphical representation of noise results for season II is given in Figure 6.14.

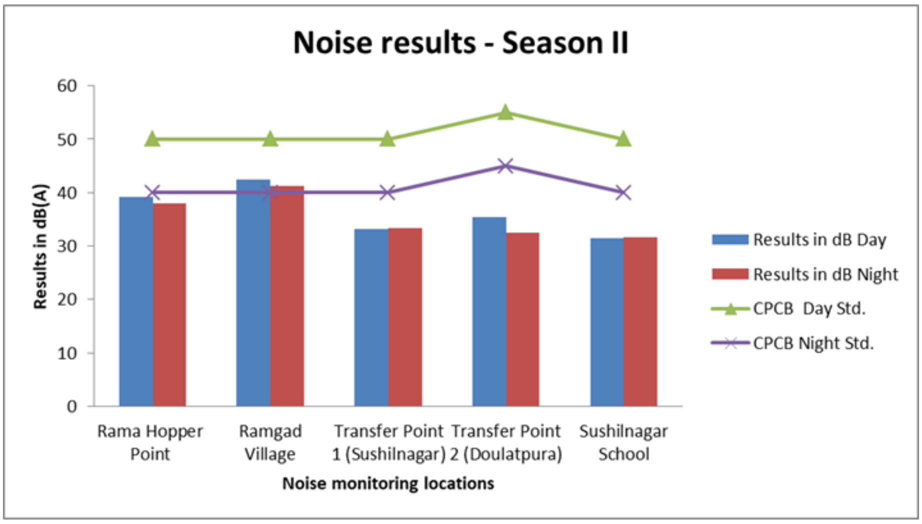


Figure 6.14 Graphical representation of noise results – season II

Results reveal that, the overall noise levels in the study area ranged from 31.49 to 39.12 dB(A) for day time and 31.61 to 41.20 dB(A) for night time. In day time the noise level in Rama study area, all are well within the CPCB Standards but during the night time in Ramgad village it has exceeded the standards, even though there is no construction and operational activities in the Rama study area the sound recorded is little higher because the Ramgad is the only village present amidst of Rama mining area and most of the trucks which transfer the ore are from this village only, and the sound recorded is more because of the movement of trucks (Between 3 Am to 6 Am) and natural sounds added to it.

6.1.4.3 Season III

During third season noise monitoring was conducted in four locations. The results are given in Table 6.14.

Table 6.14 Results of noise for Rama DHPC season III

Sl No	Locations	Zone	CPCB Standards in dB(A)		Results in dB(A)	
			Leq (Day)	Leq (Night)	Leq (Day)	Leq (Night)
1	Rama Hopper point	Silence Zone	50	40	36.65	35.57
2	Ramgad Village	Silence Zone	50	40	39.24	41.65
3	Transfer Point 1 (Sushilnagar)	Silence Zone	50	40	35.16	35.46
4	Transfer Point 2 (Doulatpura)	Residential Area	55	45	33.62	32.97
5	Sushilnagar School	Silence Zone	50	40	46.84	47.24

Graphical representation of noise results for season III is given in Figure 6.15.

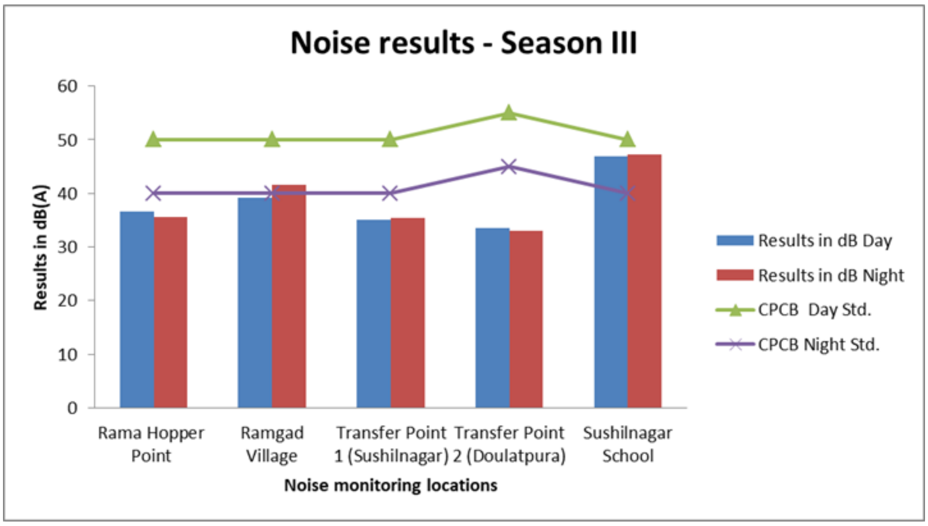


Figure 6.15 Graphical representation of noise results – season III

Results reveal that, the overall noise levels in the study area ranged from 33.62 to 46.84 dB (A) for day time and from 32.97 to 47.24 dB(A) during night times. In day time the noise level in Rama study area are well within the CPCB standards but during the night times in Ramgad village and Sushilnagar school it has exceeded the standards, even though there is no construction and operational activities in the Rama study area, the sound recorded is higher because of the movement of trucks (Between 3 Am to 6 Am) and natural sounds added to it.

6.1.4.4 Discussion

There are no construction activities or operation of mining machineries. This DHPC area consists of silence zone such as Rama hopper point, Transfer point 2 (Doulatpura) and Sushilnagar school located at the distance of 150 m, 170 m and 500 m from the DHPC corridor line respectively. During second season the average day time and night time noise levels ranged from 33.62 dB (A) to 46.84 dB(A) and from 32.97 dB(A) to 47.24 dB(A) higher compared to that of third season day time (31.49 dB (A) to 39.12 dB(A)) and night time noise levels (31.61 dB (A) to 37.92 dB(A)). Residential area consists of Ramgad village and Transfer point 1 (Sushilnagar) present at a distance of 600 m and 500 m from the DHPC corridor. Ramgad village recorded higher noise levels during day time (42.46 dB(A)) (Season II) and night time noise levels (41.65 dB(A)) (Season III). Average night time noise levels (41.65 dB(A)) recorded at Ramgad village in Season III was higher than the day time noise levels (39.24 dB(A)).This may be due to the movement of large number of trucks (Between 3 Am to 6 Am) and natural sounds added to it.

6.1.5 ToR V – Soil quality

6.1.5.1 Season I

During the first season, samples were collected from Ramgad, Siddapura and Sushilnagar. Results of which are given in Table 6.15.

Table 6.15 Results of soil quality for season I

Sl No	Parameters	Units	Ramgad	Siddapura	Sushilnagar
1	Bulk density	g/cm^3	1.7	1.28	1.28
2	Porosity	%	35.84	51.69	51.69
3	pH	--	7.4	7.2	7.5
4	Electrical Conductivity	µS/cm	129	491	720
5	Sodium	ppm	0.26	0.63	0.67
6	Phosphate	mg/kg	51.42	28.92	30.14
7	Potassium	ppm	2200	1250	2100
8	Calcium	meq/100g	34	118	136
9	Magnesium	meq/100g	12	40	47
10	Chloride	ppm	0.8	0.8	0.4
11	Nitrate	mg/kg	2.80	11.64	5.65
12	Sulphate	mg/kg	32.12	36.13	29.93
13	Water Holding Capacity	%	43.3	65	60
14	Sodium Adsorption Ratio	%	0.076	0.10	0.099
15	Exchangeable Sodium Percentage	%	0.011	0.044	0.029
16	Sand	%	77.1	79.6	57.6
17	Silt	%	8.7	9.2	19.2
18	Clay	%	14	11.1	23
19	Organic Carbon	%	0.51	0.6	0.77
20	Organic Matter	%	0.89	1.04	1.33

Note: BDL - Below Detection Level, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, meq/100g - Milliequivalent per hundred gram, mg/kg - Milligram per kilogram, % - Percentage.

pH in the study area ranged between 7.2 to 7.5. Highest pH was recorded at Sushilnagar (7.5) and overall soil pH in the study area was found to be near neutral to alkaline. Graphical representation is given in Figure 6.16.

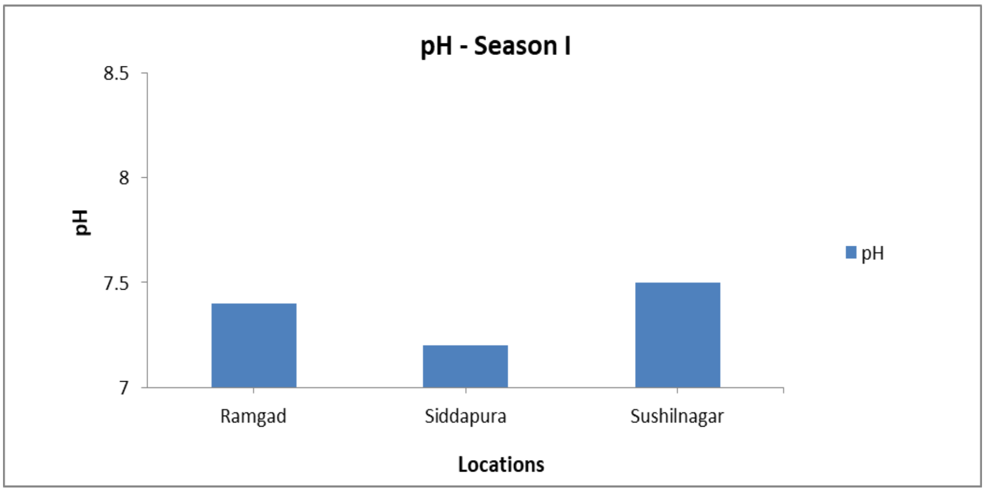


Figure 6.16 Graphical representation of pH of season I

Electrical conductivity is the measure of amount of salts present in the soil. Electrical conductivity ranged from 129 to 720 µS/cm with highest observed in Sushilnagar (720 µS/cm). Results showed sufficient amount of salts in the soil samples of the study area. Graphical representation is given in Figure 6.17.

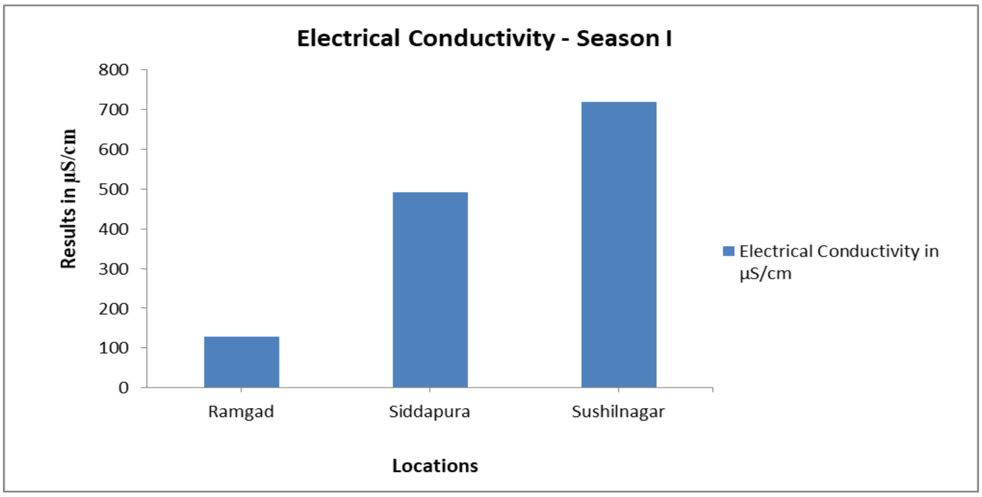


Figure 6.17 Graphical representation of Electrical Conductivity of season I

Sand, silt and clay content in soil samples ranged from 57.6% to 79.6%, 8.7% to 19.2% and 11.1% to 23% respectively. Hydrological Soil Group (HSG) classification revealed that the major type of soil present in the study area is Silt or Loam (HSG - B) as shown in Table 6.16 and the classification was based on Table 4.19. Graphical representation is given in Figure 6.18.

Table 6.16 Sand, clay percentage and HSG classification

Sl No	Location	Sand (%)	Clay (%)	HSG
1	Ramgad	77.1	14	Silt or Loam
2	Siddapura	79.6	11.1	Silt or Loam
3	Sushilnagar	57.6	23	Silt or Loam

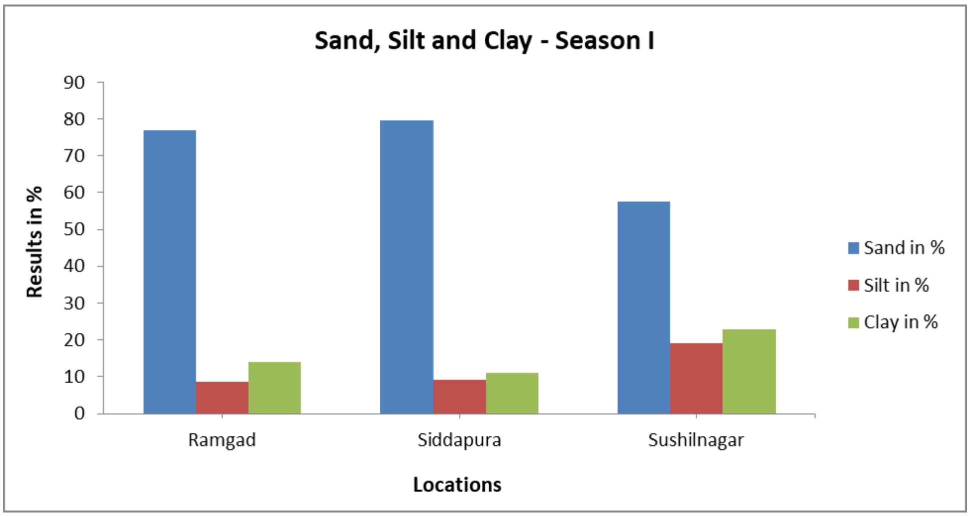


Figure 6.18 Graphical representation of sand, silt and clay for season I

6.1.5.2 Season II

During the second season samples were collected from Ramgad, Radhanagar, Sushilnagar School and Doulatpura and the results of which are given in the Table 6.17.

Table 6.17 Results of soil quality for season II

Sl No	Parameters	Units	Ramgad	Radhanagar	Sushilnagar school	Doulatpura
1	Bulk density	g/cm^3	1.442	1.305	1.313	1.305
2	Porosity	%	45.6	50.75	50.47	50.75
3	pH	--	7.69	7.63	7.73	7.89
4	Electrical Conductivity	µS/cm	89	236	268	270
5	Sodium	ppm	55	190	210	195
6	Phosphate	mg/kg	12.87	10.71	105	33.21
7	Potassium	ppm	225	95	205	420
8	Calcium	meq/100g	43	130	167	162
9	Magnesium	meq/100g	25	112	33	132
10	Chloride	ppm	21.99	31.49	BDL	
11	Nitrate	mg/kg	9.02	4.75	3.89	3.56
12	Sulphate	mg/kg	58.1	47.3	36.5	61.31

13	Water Holding Capacity	%	53.33	63.33	63.33	66.67
14	Sodium Adsorption Ratio	%	0.13	0.238	0.289	0.221
15	Exchangeable Sodium Percentage	%	0.35	0.34	0.45	0.29
16	Sand	%	58	53.58	48.38	19.23
17	Silt	%	34	28.56	32.26	53.85
18	Clay	%	8.1	17.85	19.36	26.92
19	Organic Carbon	%	0.44	2.54	0.51	0.57
20	Organic Matter	%	0.76	4.37	0.87	0.99
Note: BDL - Below Detection Level, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, meq/100g - Milliequivalent per hundred gram, mg/kg - Milligram per kilogram, % - Percentage.						

pH in the study area ranged between 7.63 to 7.89. Highest pH was recorded at Doulatpura (7.89) and overall soil pH in the study area was found to be near alkaline. Graphical representation is given in Figure 6.19.

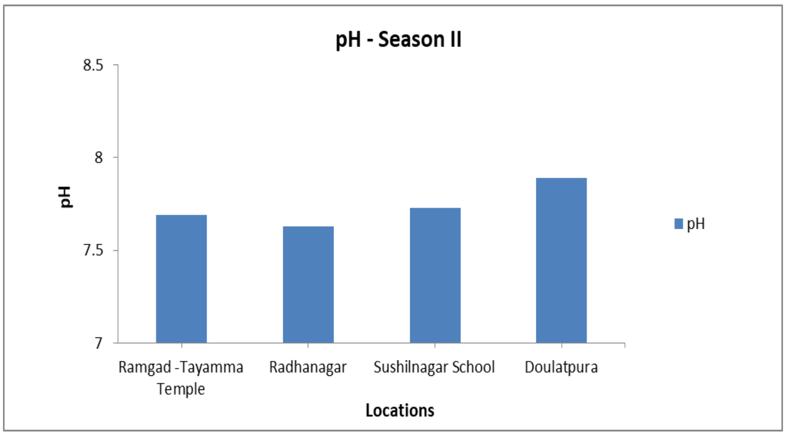


Figure 6.19 Graphical representation of pH of season II

Electrical conductivity is the measure of amount of salts present in the soil. Electrical conductivity ranged from 89 to 270 µS/cm with highest being observed in Doulatpura (270 µS/cm). Results showed sufficient amount of salts in the soil samples of the study area. Graphical representation is given in Figure 6.20.

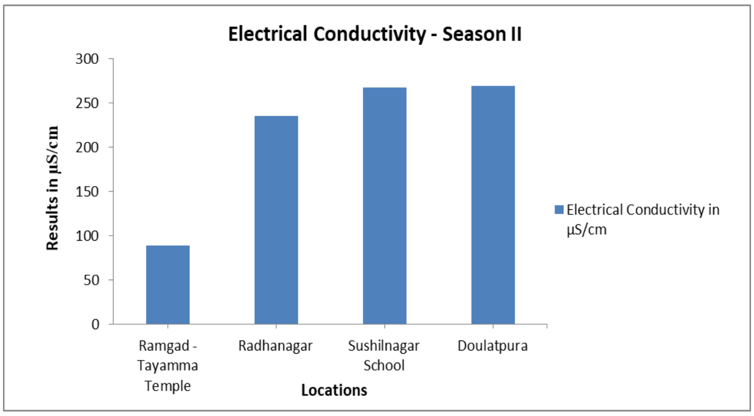


Figure 6.20 Graphical representation of Electrical Conductivity of season II

Sand, silt and clay content in soil samples ranged from 19.2% to 58%, from 28.5% to 53.8% and from 8.1% to 26.9% respectively. Hydrological Soil Group (HSG) classification revealed that the major type of soil present in the study area is Silt or Loam (HSG - B) as shown in Table 6.18 and the classification was based on Table 4.19. Graphical representation is given in Figure 6.21.

Table 6.18 Sand, clay percentage and HSG classification

Sl No	Location	Sand (%)	Clay (%)	HSG
1	Ramgad - Tayamma Temple	58	8.1	Silt or Loam
2	Radhanagar	53.58	17.85	Silt or Loam
3	Sushilnagar School	48.38	19.36	Silt or Loam
4	Doulatpura	19.23	26.92	Sandy Clay Loam

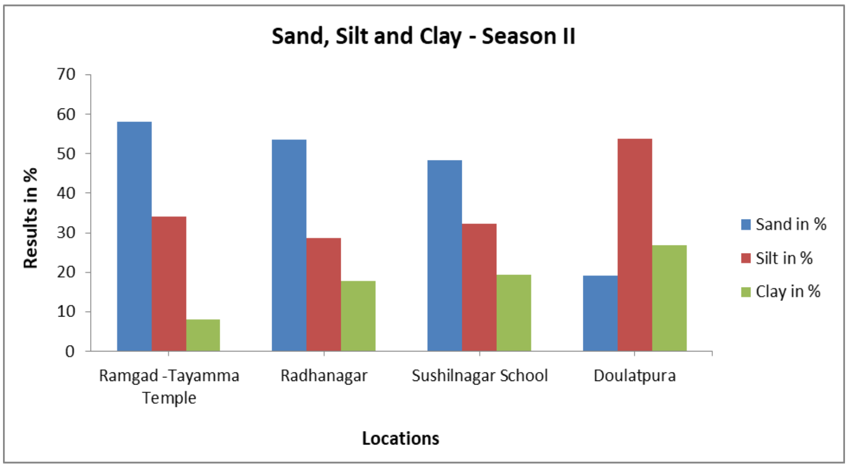


Figure 6.21 Graphical representation of sand, silt and clay of season II

6.1.5.3 Season III

During the third season, samples were collected from 3 locations viz., Ramgad, Radhanagar, Sushilnagar School and Doulatpura and the results of which are given in Table 6.19.

Table 6.19 Results of soil quality for season III

Sl No	Parameters	Units	Ramgad	Radhanagar	Sushilnagar school	Doulatpura
1	Bulk density	g/cm^3	1.74	1.3	1.44	1.19
2	Porosity	%	34.3	50.9	45.7	55.1
3	pH	--	7.56	7.4	7.02	7.48
4	Electrical Conductivity	µS/cm	104	362	295	426
5	Calcium	meq/100g	95	130	130	325
6	Magnesium	meq/100g	30	125	85	120
7	Sodium	meq/100g	0.87	3.61	4.04	4.78
8	Potassium	ppm	1120	1807	1064	1599
9	Chloride	meq/100g	1.2	1.8	BDL	BDL
10	Nitrate	mg/kg	4.16	15.33	10.23	16.85
11	Sulphate	mg/kg	46.68	182.16	14.84	92.87
12	Phosphate	mg/kg	9.67	32.23	71.65	43.39
13	Water Holding Capacity	%	49.2	62.8	61.2	65.6
14	Sodium Adsorption Ratio	--	0.2	0.5	0.6	0.5
15	Exchangeable Sodium Percentage	%	0.1	0.2	0.3	0.2
16	Sand	%	76.2	71.3	65.2	72.5
17	Silt	%	16.2	13.9	26.1	23.2
18	Clay	%	7.6	14.8	8.7	4.3
19	Organic Carbon	%	0.13	1.08	0.27	0.34
20	Organic Matter	%	0.24	1.86	0.48	0.6

Note: BDL - Below Detection Level, g/cm^3- Gram per centimetre cube, µS/cm - Microsiemens per centimetre, meq/100g - Milliequivalent per hundred gram, mg/kg - Milligram per kilogram, % - Percentage.

pH in the study area ranged between 7.02 to 7.56. Highest pH was recorded at Ramgad-Tayamma temple (7.56) and overall soil pH in the study area was found to be near neutral to alkaline. Graphical representation is given in Figure 6.22.

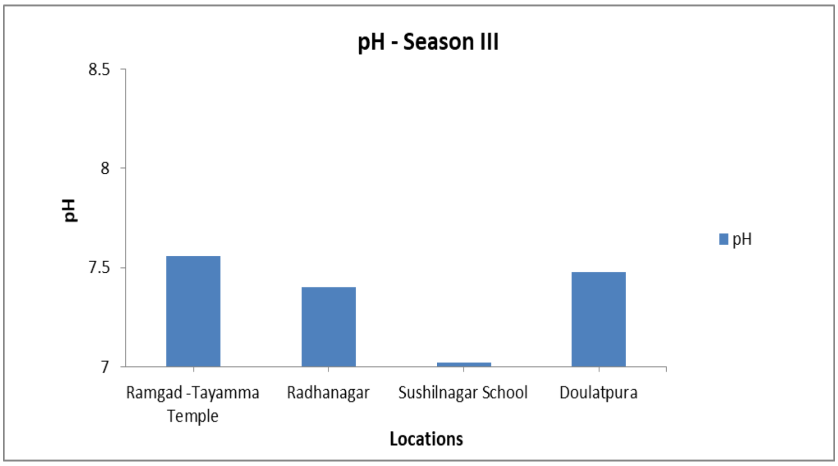


Figure 6.22 Graphical representation of pH of season III

Electrical conductivity is the measure of amount of salts present in the soil. Electrical conductivity ranged from 104 to 426 µS/cm with highest observed in Doulatpura (426 µS/cm). Results showed sufficient amount of salts in the soil samples of the study area. Graphical representation is given in Figure 6.23.

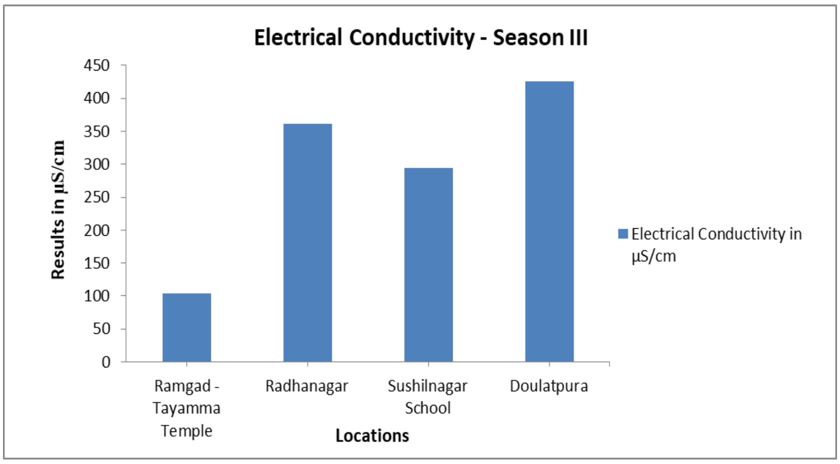


Figure 6.23 Graphical representation of Electrical Conductivity of season III

Sand, silt and clay content in soil samples ranged from 65.2% to 76.2%, from13.9% to 26.1% and from 4.3% to 14.8% respectively. Hydrological Soil Group (HSG) classification revealed that the soil present in the study area is Silt or Loam (HSG - B) as shown in Table 6.20 and the classification was based on Table 4.19. Graphical representation is given in Figure 6.24.

Table 6.20 Sand, clay percentage and HSG classification

Sl No	Location	Sand (%)	Clay (%)	HSG
1	Ramgad - Tayamma Temple	76.2	7.6	Silt or Loam
2	Radhanagar	71.3	14.8	Silt or Loam
3	Sushilnagar School	65.2	8.7	Silt or Loam
4	Doulatpura	72.5	4.3	Silt or Loam

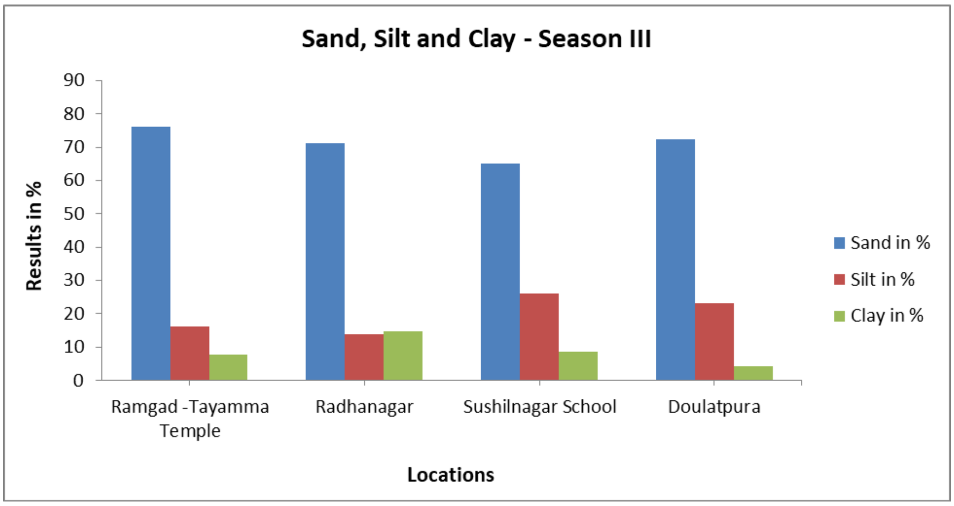


Figure 6.24 Graphical representation of sand, silt and clay of season III

6.1.5.4 Discussion

In all seasons the soil pH was found to be alkaline. Higher Electrical Conductivity was observed in all samples and seasons. Hydrological Soil Group classification revealed that Silt or Loam type of soil is present in the study area.

6.1.6 ToR VI- Meteorological monitoring

6.1.6.1 Season I

In first season, secondary data was collected from M/s JSW, Ballari and results are enclosed as Annexure IV.

6.1.6.2 Season II

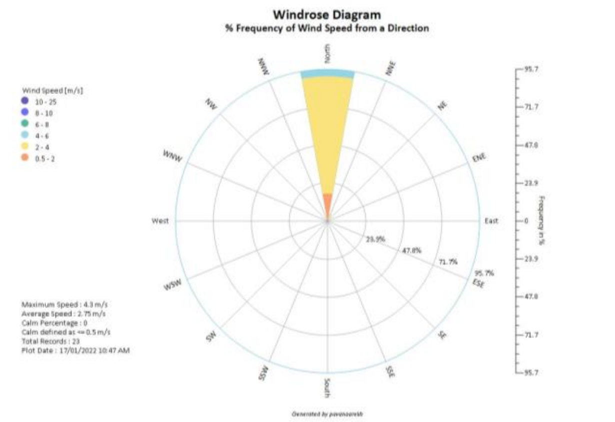
Primary data was collected from the meteorological station installed at M/s Rama Iron ore mines, data related to temperature, rainfall, wind direction, relative humidity, and wind speed were collected for October to December -2021. The primary data collected for Rama DHPC were analyzed using a wind rose diagram drawn by Pavanaarekh software. The meteorological data for season II is given in Table 6.21.

Table 6.21 Results of meteorological data for M/s Rama Iron ore mines

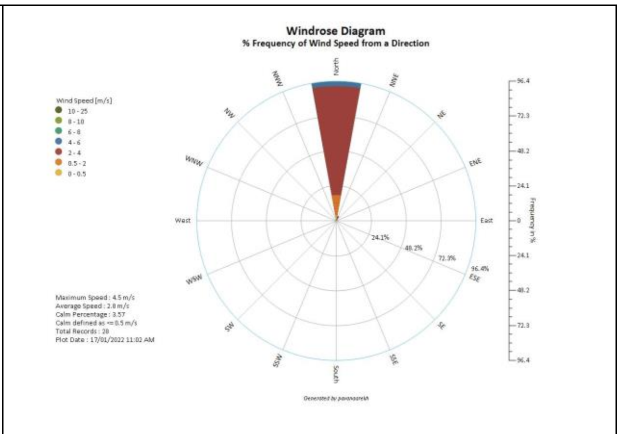
Sl No	Month	Year		Temperature (°C)	Rainfall (mm)	Humidity (%)	Wind speed m/s	Dominant wind direction
1	October	2021	Max	30.3	12.5	91.5	4.3	North
			Min	18.5	0.5	72	1.7	
			Avg		27.5	89.28	2.74	

2	November	2021	Max	27.5	14	91.5	4.5	North
			Min	16.7	0.5	91.5	0.8	
			Avg		44	91.5	2.90	
3	December	2021	Max	29.7	0	100	3.5	North
			Min	14.3	0	61.7	0.8	
			Avg		0	89.13	2.1	

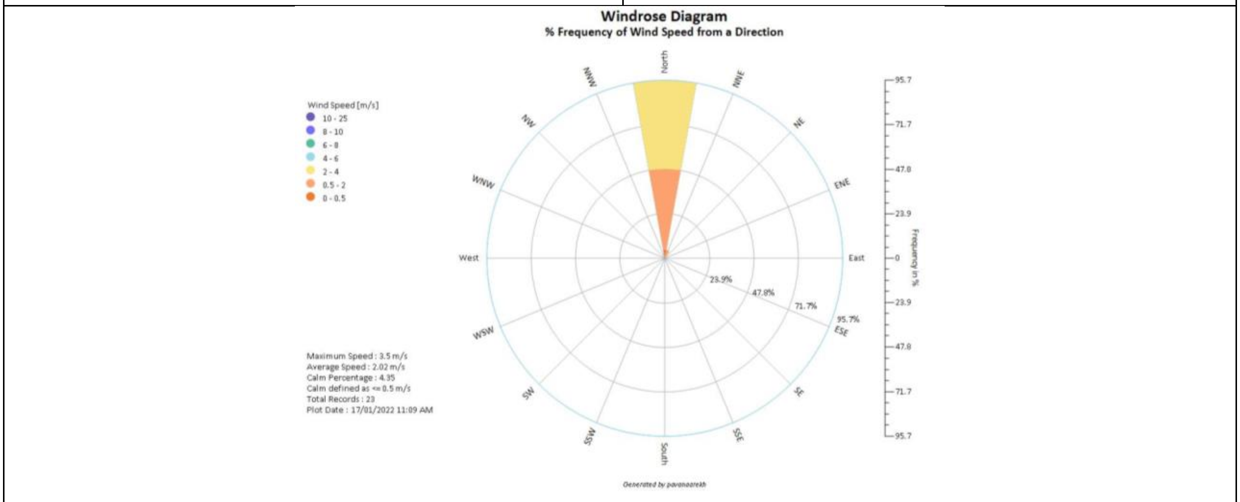
During season II (October 2021 to November 2021) the highest temperature was recorded as 30.3°C on 23.10.2021 and the lowest temperature was observed to be 14.3°C on 19.12.2021. Maximum humidity of 100% (December 2021) and a minimum of 61.7% (December 2021) were recorded. The heaviest rainfall was recorded on 09.11.2021 i.e., 14 mm rain. The plotted data showed that the predominant wind direction was North and wind rose plot are given in Figure 6.25.



October 2021



November 2021



December 2021

Figure 6.25 Wind rose plot for season II

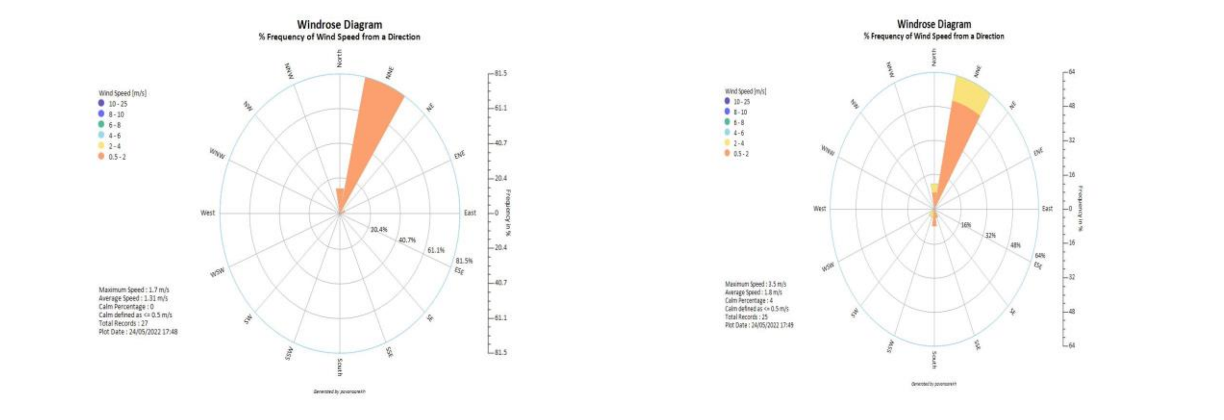
6.1.6.3 Season III

Primary data was collected from the meteorological station installed at M/s Rama Iron ore mines, data related to temperature, rainfall, wind direction, relative humidity, and wind speed were collected for season III. The primary data collected for Rama DHPC were analyzed using a wind rose diagram drawn by Pavanaarekh software. The meteorological data for season III is given in Table 6.22.

Table 6.22 Results of meteorological condition for season III

Sl No	Month	Year		Temperature (°C)	Rainfall (mm)	Humidity (%)	Wind speed (m/s)	Dominant wind direction
1	February	2022	Max	33.2	0	100	1.7	North-North-East (NNE)
			Min	14.1	0	89.5	0.6	
			Avg	-	0	99.13	1.31	
2	March	2022	Max	36.5	1	100	3.5	North-North-East (NNE)
			Min	17	0	55.5	1.5	
			Avg	-	0.04	82.21	1.80	

The maximum temperature recorded in Rama study area is 36.5ºC on 29.03.2022 and minimum temperature is 14.1ºC on 05.02.2022 with 55.5% of minimum and 100% of maximum relative humidity on 12.03.2022 and 02.02.2022 respectively. Predominant wind direction was found to be North-North-East during Season III and wind rose plot of same is given in Figure 6.26.



February 2022	March 2022

Figure 6.26 Wind rose plot for season III

7 Socio-Economic Survey

To assess the socio economic conditions of the people in the project influenced villages

7.1 Results and discussions

7.1.1 Devadari DHPC

The details of villages considered for survey is given in Table 7.1.

Table 7.1 Details of villages considered for survey in Devadari DHPC

Sl No	Name of Village	Total Households (Census, 2011)	10 % of Households	No of Households Surveyed
1	Bhujanganagar	1063	107	108
2	Devagiri	701	71	71
3	Devaramallapura	424	43	46
4	Dharmapura	346	35	35
5	Ankanamahal	374	38	39
6	Karthikeshwara	327	33	33
7	Krishnanagar	1354	136	136
8	Lakshmipura	426	43	43
9	Somalapura	153	16	16
10	Tonisigeri	254	26	27
11	Vittalanagar	206	21	21
12	Yashwanthnagar	1270	127	127
13	Narasapura	461	47	47
14	Ranjithpura	267	40	45
	Total	**7626**	**783**	**794**

Results of socio- economic survey are given as follows

7.1.1.1 General information

A total of 794 households were interviewed in 14 villages of Devadari DHPC. The results revealed that 83.8% belong to Hindu community out of which Scheduled Caste/Scheduled Tribes (SC/ST) were 39.6%. About 15.6% were Muslims and 0.6% was Christians. About

84.4% spoke Kannada. Illiterates (38.2%) were found to be more followed by high school (27.7%) and primary school (23.6%) education with minimal percentage of graduates (10.3%). The occupation in the region was more in unorganised sector (50.4%) and farming sector (27.7%). Results are given in Table 7.2.

Table 7.2 Results of socio-economic survey in Devadari DHPC

Sl No	Parameters		No of respondents	Percentage of respondents (%)
1	Religion	Hindu	666	83.8
		Muslim	124	15.6
		Christian	5	0.6
		Others	0	0
2	Caste	GM	196	24.6
		OBC	283	35.6
		SC/ST	315	39.6
		Others	0	0
3	Mother tongue	Kannada	671	84.4
		Telugu	0	0
		Hindi	0	0
		Others	123	15.5
4	Qualification of family head	Primary	188	23.6
		High school	220	27.7
		Degree	82	10.3
		None	304	38.2
5	Occupation of family head	Farmer	220	27.7
		Govt employee	11	1.4
		Private	162	20.4
		Others	401	50.4
***Note:** GM - General Merit; OBC - Other Backward Class; SC/ST -Scheduled Caste/Scheduled Tribes.				

Graphical representation of general information and Education & Occupation information for Devadari study area is given in Figure 7.1 and 7.2 respectively.

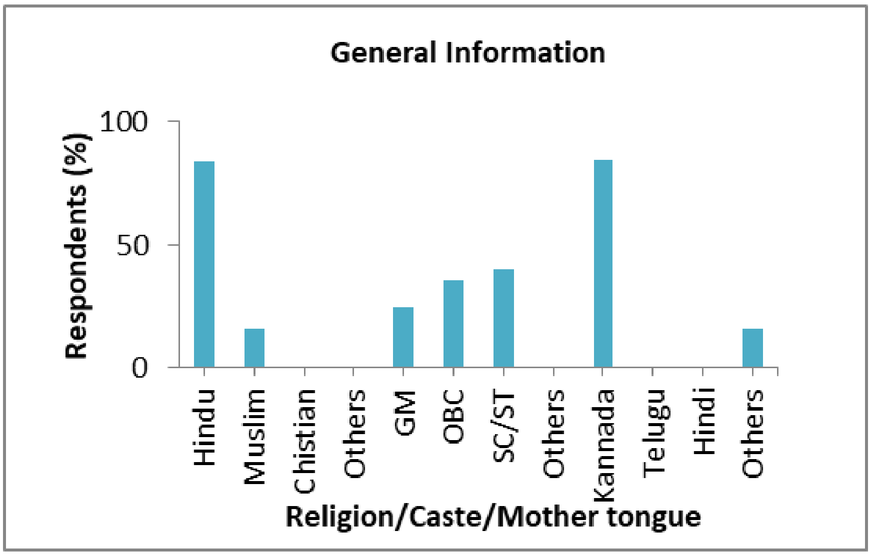


Figure 7.1 General information of Devadari DHPC

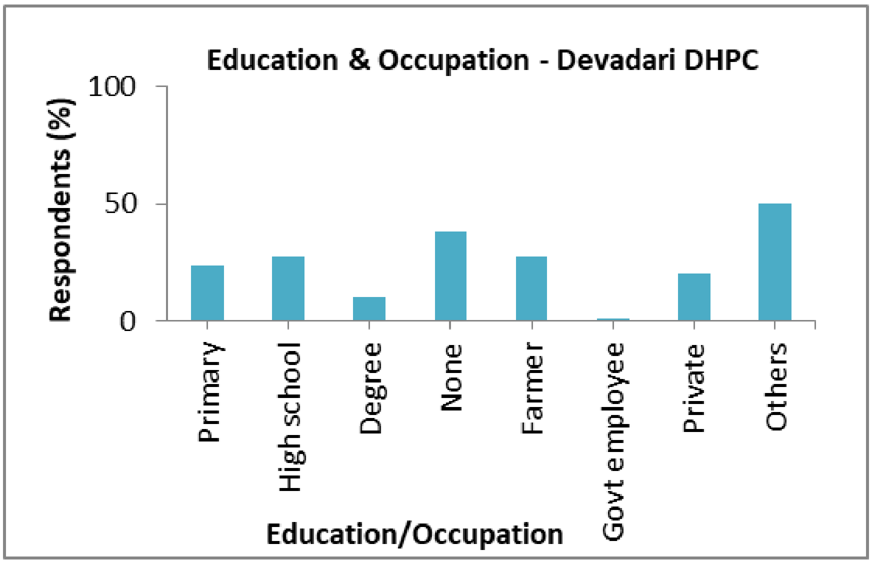


Figure 7.2 Education & Occupation information – Devadari DHPC

7.1.1.2 Economic status

The economic status of surveyed families was found out using the questionnaires. The annual income of majority families (42.3%) was found to be more than one lakh (Figure 7.3). 78.5% and 59.4% families owned buildings and vehicles while 77.7% of property had sole ownership (Figure 7.4). Only 37.9% of families had land ownership. 53.7% and 33.8% of families lived in sheet and concrete houses respectively. All the households had electricity connection (100%). The major source of drinking water was found to be RO filter water (76.2%). Livestock such as cattle's (11.3%), sheep (3.4%) and chicks/ poultry (2.5%) were also owned by surveyed families. The results of the economic status are given in Table 7.3.

Table 7.3 Results of economic status in Devadari DHPC

Sl No	Parameters		No of respondents	Percentage of respondents (%)
1	Annual income of family head	<100000	277	34.8
		>100000	336	42.3
		>200000	152	19.1
		>400000	25	3.1
2	Type of property	Land	301	37.9
		Building	624	78.5
		Vehicle	472	59.4
		Others	0	0.0
3	Ownership of property	Own	618	77.7
		Joint	6	0.7
		Rent	172	21.6
		None	0	0.0
4	Type of house	Concrete house	269	33.8
		Tiles house	53	6.7
		Sheet house	427	53.7
		Others	46	5.8
5	Electricity connection	Yes	793	99.7
		No	1	0.1
6	Drinking water source	Borewell	181	22.8
		Surface water	7	0.9
		Open well	0	0.0
		Others	606	76.2
7	Source of water for agriculture	Rain water	257	32.3
		Ground water	66	8.3
		Surface water	0	0.0
		Others	0	0.0
8	Livestock information	Cattles	90	11.3
		Sheep	27	3.4
		Chickens	20	2.5
		Others	0	0.0

9	Own vehicle	Two wheeler	445	55.9
		Four wheeler	23	2.9
		Others	11	1.4
		None	291	36.6
10	Fuel used for cooking	LPG	613	77.1
		Firewood	181	22.8
		Biogas	0	0.0
		Others	0	0.0
11	Agriculture machinery	Tractor/Tiller	6	0.7
		Bullock cart	19	2.4
		Others	1	0.1
		None	723	90.9

Graphical representation of annual income and property type & ownership is given in Figure 7.3 and 7.4 respectively.

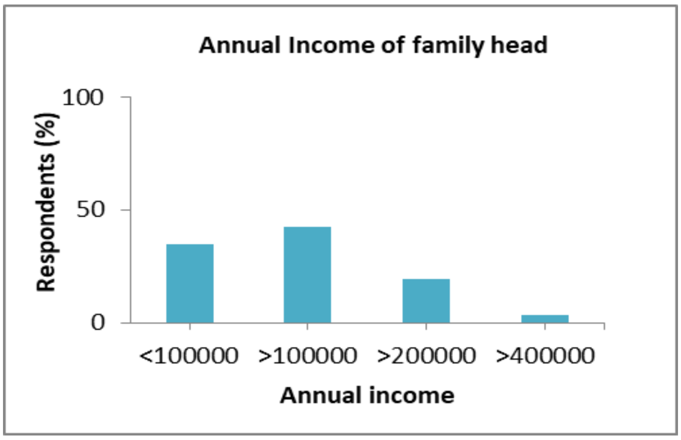


Figure 7.3 Graphical representation of annual income for Devadari DHPC

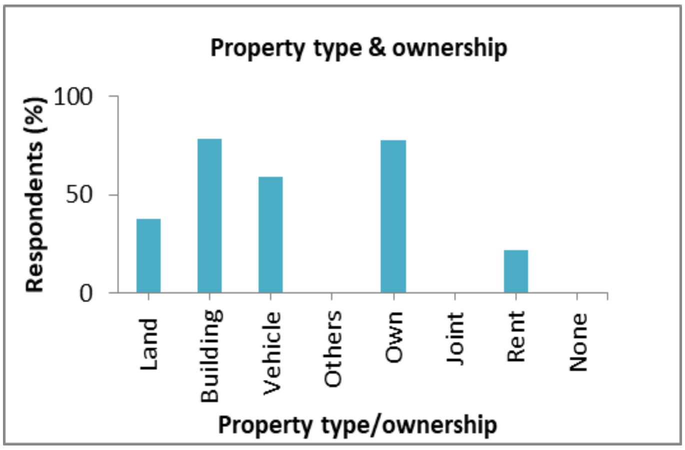


Figure 7.4 Graphical representation of property type and ownership – Devadari DHPC

7.1.1.3 Dependency on mineral transportation for livelihood

Although majority of the surveyed families (85.4%) did not have dependency on mineral transportation for livelihood, however 2.3% of the families have direct dependency and 0.6% families had indirect dependency on mineral transportation. About 2.5% of the surveyed population depend on vehicles for their livelihood, and about 0.6% of surveyed population have small/ petty shops along the DHPC area. The results of the dependency and extent of financial effects are given in Table 7.4.

Table 7.4 Results of dependency on mineral transportation in Devadari DHPC

Sl No	Parameters		No of respondents	Percentage of respondents (%)
1	Family dependent on mineral transportation for livelihood.	Directly dependent	18	2.3
		Indirectly dependent	5	0.6
		Not dependent	679	85.4
2	Type of dependency on livelihood	Transport vehicle owner	0	0
		Vehicle driver/cleaner	22	2.8
		Shops on route	1	0.1
3	Financial impact of DHPC operation on family	Yes	23	2.9
		No	679	85.4
4	Extent of effect on livelihood due to DHPC	≤ 25%	13	1.6
		≤ 50%	9	1.1
		≤ 75%	1	0.1
		≤ 100%	0	0

Graphical representation of financial dependency is given in Figure 7.5 and 7.6 respectively.

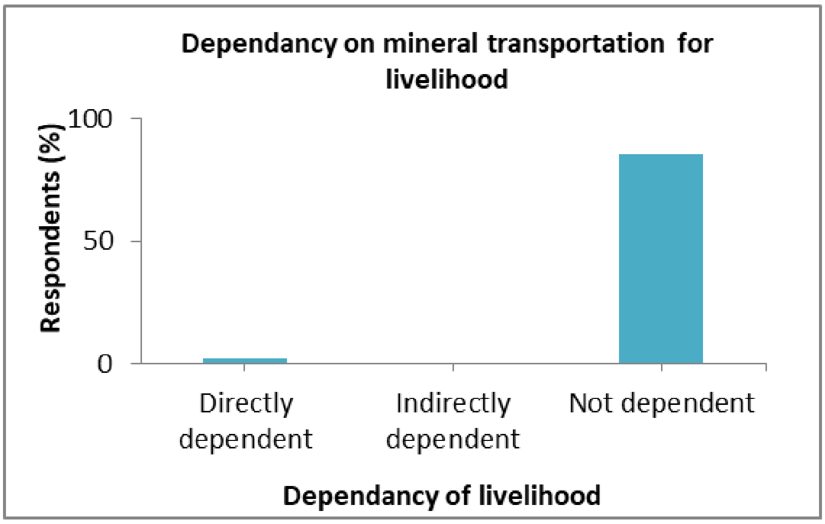


Figure 7.5 Dependency of mineral transportation for livelihood – Devadari DHPC

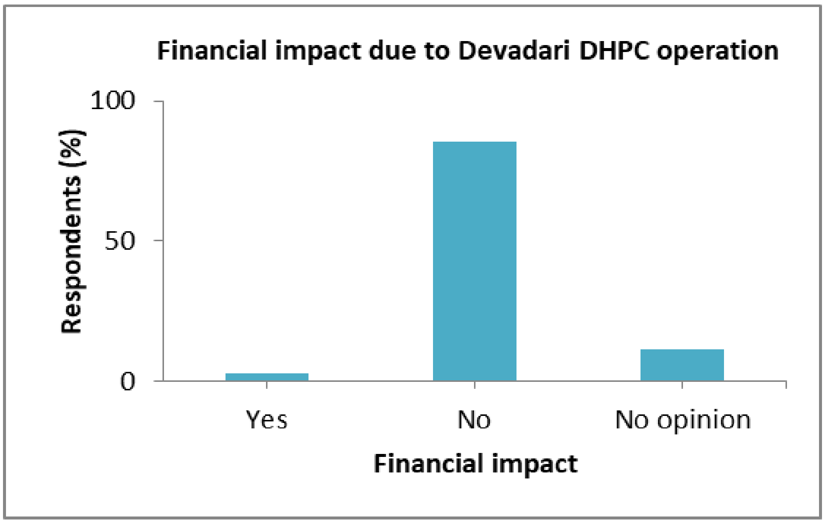


Figure 7.6 Financial impact due to operation of Devadari DHPC

7.1.1.4 Local health information

The opinion of the surrounding environmental status was enquired, in which 35.3% and 20.7% of surveyed families have an opinion that the environment is highly and moderately polluted. 29.3% of families have an opinion that the surrounding environment is less polluted while 0.5% of families gave an opinion that the environment is clean. The health facilities and illness of family members along with other health impacts are mentioned in Table 7.5.

Table 7.5 Results of health information in Devadari DHPC

Sl No	Parameters		No of respondents	Percentage of respondents (%)
1	Status of the surrounding environment	Highly polluted	281	35.3
		Moderately polluted	165	20.7
		Less polluted	233	29.3
		Clean	4	0.5
2	Health facilities	Govt hospital	0	0
		Private hospital	71	8.9
		Private clinic	554	69.7
		None	168	21.1
3	Family members suffering from illness	Bronchial disease	259	32.6
		Skin allergy	253	31.8
		Others	33	4.1
		None	249	31.3
4	Type of health impacts	Headache	225	28.3
		Sleep disorder	186	23.4
		Hearing loss	140	17.6
		None	261	32.8

Graphical representation of opinion on surrounding environment and health impacts is given in Figure 7.7 and 7.8 respectively.

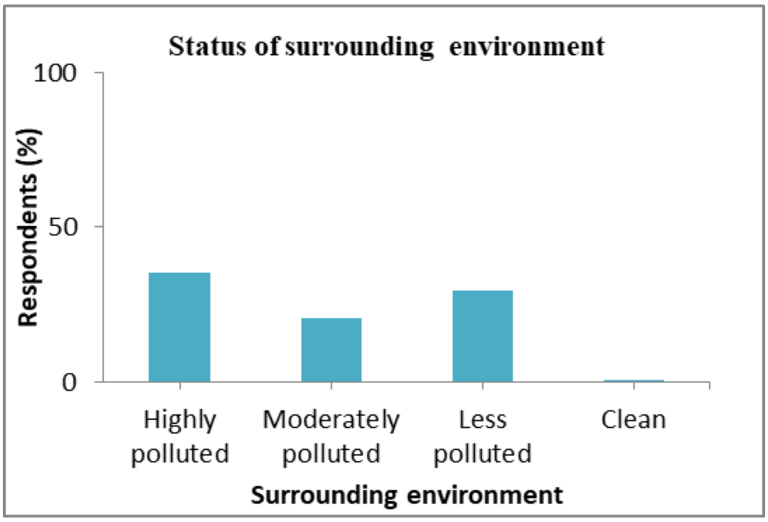


Figure 7.7 Opinion on the status of surrounding environment

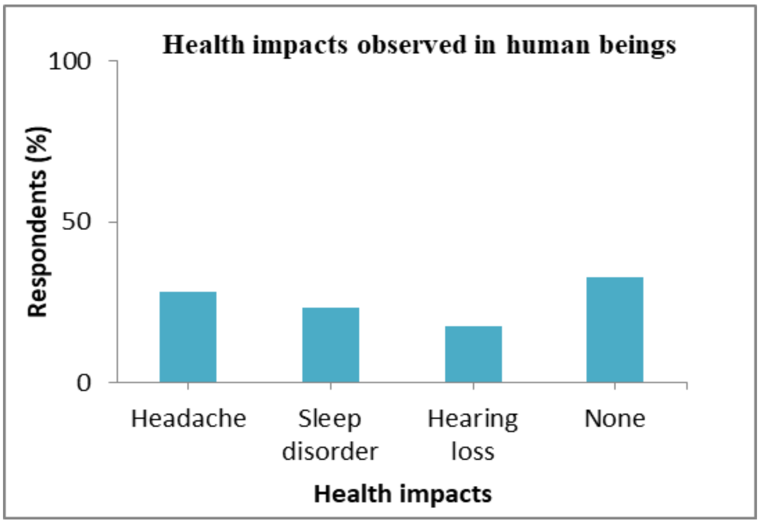


Figure 7.8 Health impacts observed in human beings

7.1.2 Tunga and Bhadra DHPC

The details of villages considered for survey is given in Table 7.6 and results of socio-economic survey are given as below:

Table 7.6 Details of villages considered for survey in Tunga and Bhadra DHPC

Sl No	Name of Village	Total Households (Census, 2011)	15 % of Households	No of Households Surveyed
1	Muraripura	202	31	35
2	Avinamadugu	86	13	26
3	S. Gangalapura	161	25	26
4	Bannihatti	425	64	65
5	Marutala	43	7	15
	Total	**917**	**140**	**167**

7.1.2.1 General information

Total 167 households were interviewed and results reveal that Hindu community (96.4%) were present in majority with SC/ST (47.9%) being dominant. 94.6% mother tongue was kannada and illiterates (37.1%) were more, rest had primary (32.9%) and high school (29.3%) education. Major occupation was farming (41.3%). Results are given in Table 7.7.

Table 7.7 Results of socio-economic survey

Sl No	Parameters		No of respondents	Percentage of respondents (%)
1	Religion	Hindu	161	96.4
		Muslim	6	3.6
		Christian	0	0
		Others	0	0
2	Caste	GM	33	19.8
		OBC	54	32.3
		SC/ST	80	47.9
		Others	0	0.0
3	Mother tongue	Kannada	158	94.6
		Telugu	1	0.6
		Hindi	0	0.0
		Others	8	4.8
4	Qualification of family head	Primary	55	32.9
		High school	49	29.3
		Degree	1	0.6
		None	62	37.1
5	Occupation of family head	Farmer	69	41.3
		Govt employee	4	2.4
		Private	30	18.0
		Others	64	38.3
***Note:** GM - General Merit; OBC - Other Backward Class; SC/ST -Scheduled Caste/ /Scheduled Tribes.				

Graphical representation of general information gathered and details of education & occupation is given in Figure 7.9 and 7.10 respectively.

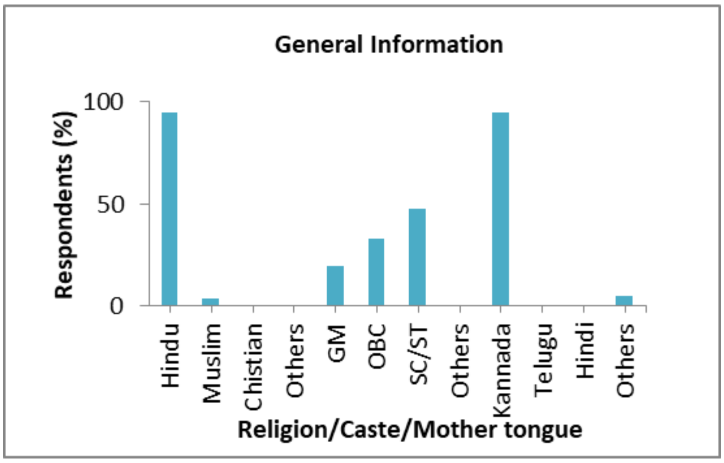


Figure 7.9 Graphical representation of general information

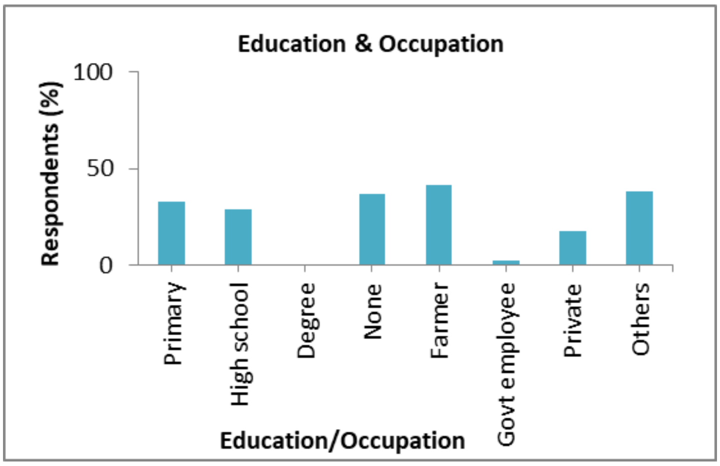


Figure 7.10 Education & Occupation information – Tunga & Bhadra DHPC

7.1.2.2 Economic status

Majority of surveyed families (38.3%) were having annual income of more than 2 Lakhs per annum. Building (94%) is the major property owned with 77.8% of property ownership being solo. Around 43.7% of surveyed families live in concrete house while 41.9% own sheet house and 100% electricity connections were recorded. 62.9% drink RO filter water and others depend on borewell, surface water etc. The cattle population of 25.1% was recorded. Large number of families own two wheelers (50.3%) and use LPG (85.6%) as fuel for cooking. Majority of households (71.3%) did not own agriculture machineries. Results are given in Table 7.8.

Table 7.8 Results of economic status in Tunga and Bhadra DHPC

Sl No	Parameters		No of respondents	Percentage of respondents (%)
1	Annual income of family head	<100000	15	9.0
		>100000	62	37.1
		>200000	64	38.3
		>400000	26	15.6
2	Type of property	Land	104	62.3
		Building	157	94.0
		Vehicle	105	62.9
		Others	0	0.0
3	Ownership of property	Own	130	77.8
		Joint	36	21.6
		Rent	1	0.6
		None	0	0.0
4	Type of house	Concrete house	73	43.7
		Tiles house	4	2.4
		Sheet house	70	41.9
		Others	20	12.0

5	Electricity connection	Yes	167	100.0
		No	0	0.0
6	Drinking water source	Bore well	61	36.5
		Surface water	1	0.6
		Open well	0	0.0
		Others	105	62.9
7	Source of water for agriculture	Rain water	102	61.1
		Ground water	11	6.6
		Surface water	0	0.0
		Others	1	0.6
8	Livestock information	Cattles	42	25.1
		Sheep	14	8.4
		Chicks	8	4.8
		Others	0	0.0
9	Livestock feeding information	Forest pasture	26	15.6
		Planted pasture	0	0.0
		Crop residue	30	18.0
		Purchased feed	9	5.4
10	Own vehicle	Two wheeler	84	50.3
		Four wheeler	14	8.4
		Others	10	6.0
		None	62	37.1
11	Fuel used for cooking	LPG	143	85.6
		Firewood	24	14.4
		Biogas	0	0.0
		Others	0	0.0
12	Agriculture machinery	Tractor/Tiller	15	9.0
		Bullock cart	7	4.2
		Others	0	0.0
		None	119	71.3

Graphical representation of annual income and property type is given in Figure 7.11 and 7.12 respectively.

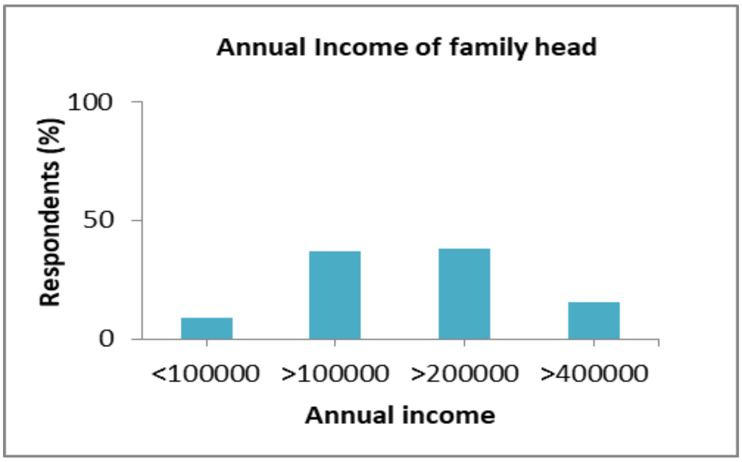


Figure 7.11 Graphical representation of annual income

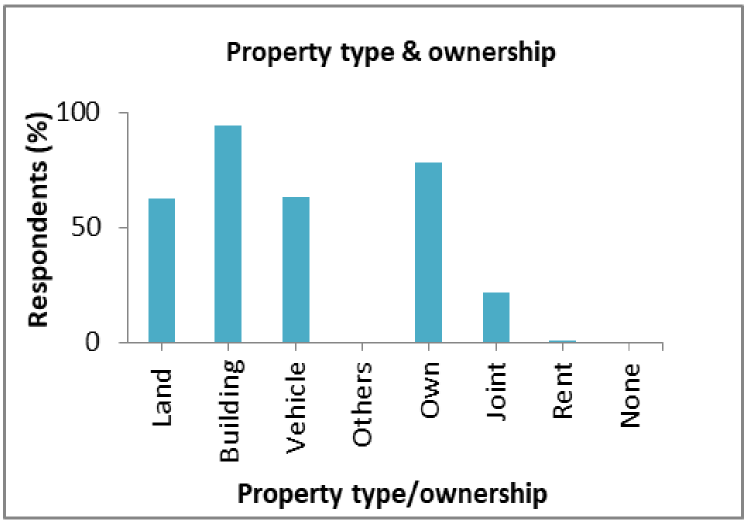


Figure 7.12 Graphical representation of property type and ownership

7.1.2.3 Local health information

Total 59.3% and 23.4% surveyed families have an opinion that the environment is moderately and highly polluted with 32.9% of private clinic as major source of health facility present. Results are given in Table 7.9.

Table 7.9 Results of health information

Sl No	Parameters		No of respondents	Percentage of respondents (%)
1	Status of the surrounding environment	Highly polluted	39	23.4
		Moderately polluted	99	59.3
		Less polluted	29	17.4
		Clean	0	0.0
2	Health facilities	Govt hospital	10	6.6
		Private hospital	0	0
		Private clinic	55	32.9
		None	102	61.1

Graphical representation of opinion of local people on environmental condition and health facilities is given in Figure 7.13 and 7.14 respectively.

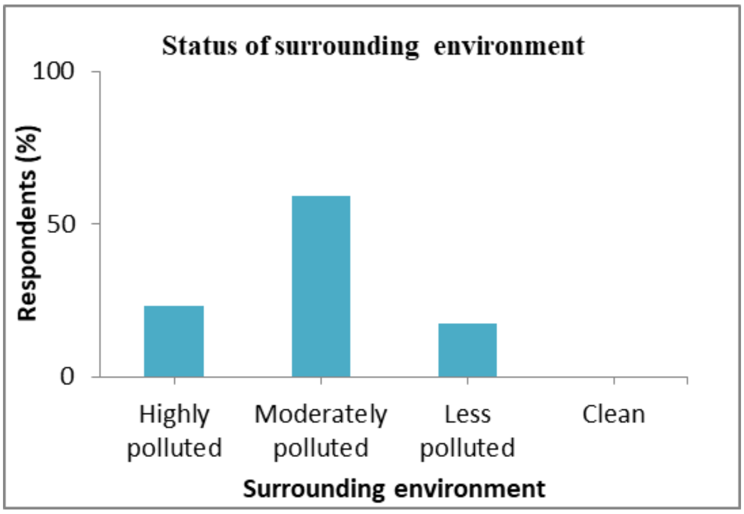


Figure 7.13 Opinion on the status of surrounding environment

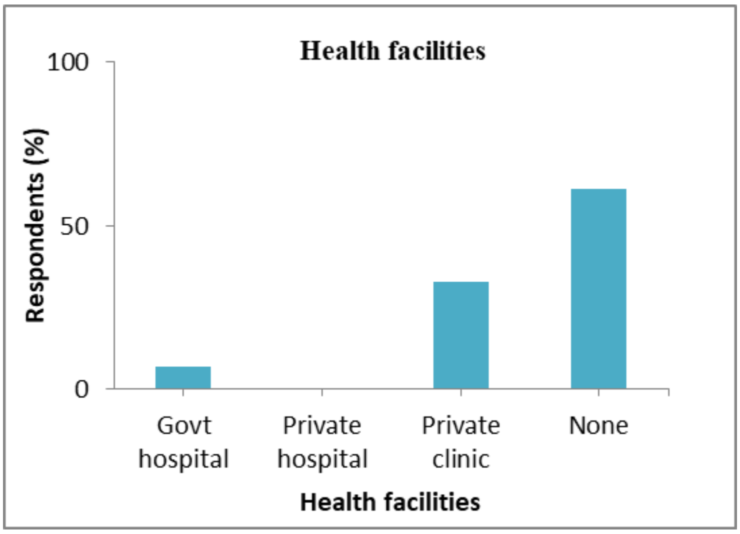


Figure 7.14 Health facilities in the study area

7.1.2.4 Environment conditions

Majority of surveyed families have an opinion that the air (39.5%), water (47.9%) and noise (49.7%) is highly polluted while in case of soil (56.9%) it's moderately polluted. Results are given in Table 7.10.

Table 7.10 Results of environment conditions in Tunga and Bhadra DHPC

SL No	Parameters		No of respondents	Percentage of respondents (%)
1	Opinion on air pollution	Low	19	11.4
		Medium	50	29.9
		High	66	39.5
		Very high	32	19.2
2	Opinion on water pollution	Low	14	8.4
		Medium	73	43.7
		High	80	47.9
		Very high	0	0.0
3	Opinion on soil pollution	Low	30	18.0
		Medium	95	56.9
		High	42	25.1
		Very high	0	0.0
4	Opinion on Noise pollution	Low	15	9.0
		Medium	58	34.7
		High	83	49.7
		Very high	11	6.6
5	Degree of geographical landscape changes in recent times	Low	10	6.0
		Medium	77	46.1
		High	68	40.7
		Very high	2	1.2
6	Corporate social responsibility (CSR) activities	Employment training	19	11.4
		Local health camp	61	36.5
		Women empowerment	15	9.0
		None	72	43.1

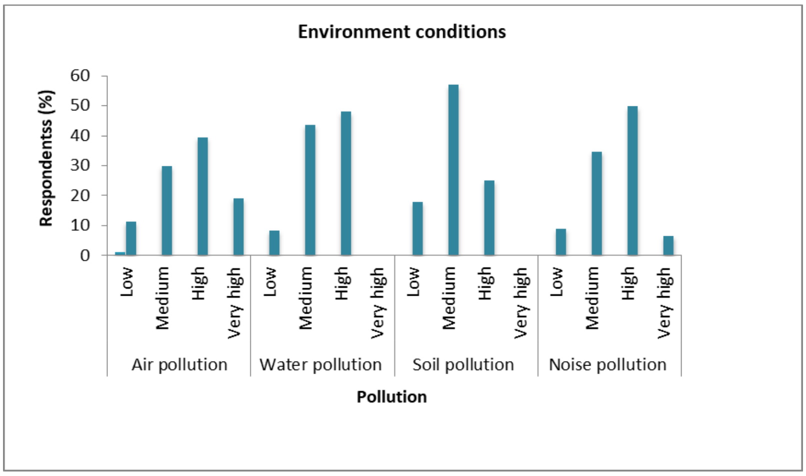


Figure 7.15 Graphical representation of pollution conditions in the environment

7.1.3 Rama DHPC

7.1.3.1 Ramgad village

Total 12 households were surveyed. 50% of surveyed population were illiterate, rest had primary (25%) and high school (25%) education. Major occupation of the families was in private sector (67%). Large proportions (58%) had annual income of more than 1 lakh and all families owned sheet house (100%). Graphs representing these details are given in Figure 7.16.

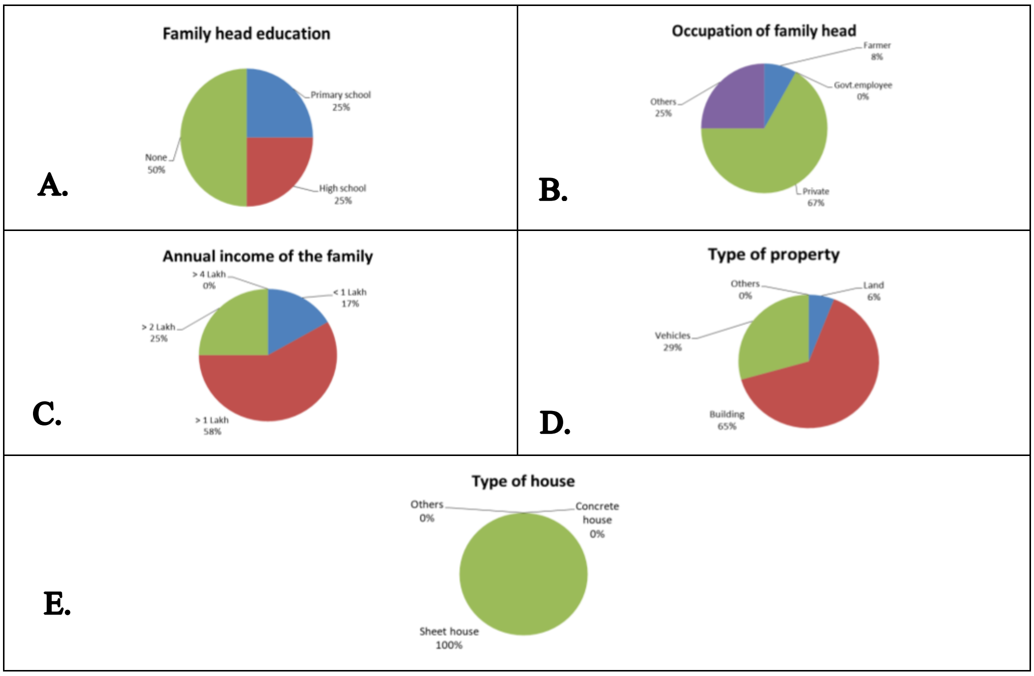


Figure 7.16 Graphical representation of socio-economic survey results - Ramgad village

(A) **Family head education** (B) **Occupation of family head** (C) **Annual income of the family** (D) **Type of the property** (E) **Type of house**

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

8.1 Land-Use/ Land-Cover (LU/LC) layer data model

The geometrically corrected Resource Sat- 2 LISS IV & within the desired framework is the primary input for LU/LC classification and mapping. Survey of India topographic map layer on 1:50K scale is used as the base layer. A good amount of collateral data on themes like wasteland, forest, vegetation etc. is used as an important source of reference for LU/LC classification Table 8.1. These legacy layers are re-projected as per the current mapping specifications before using them. The projection system followed in this study is the Projected Coordinate System: WGS 1984_UTM 43N.

To match the LU/LC classification and mapping on best possible scale using the LISS IV, the following LU/LC layer data model table was derived from SIS- DP manual (NRSC, 2009) published by NRSC (ISRO). These LU/LC classes were followed in preparing the LULC dataset for the present project.

Based on the above described inputs and the reference data, visual interpretation is carried out on 2012, 2018 and 2021 imageries. From 2012, 2018 and 2021 LU/LC classification, change detection analysis is carried out for quantifying the difference that has occurred over the period of 9 years. Apart from change detection analysis, overlay analysis is carried out, which is performed using the tools to overlay multiple feature classes to combine, erase, modify or update spatial feature, resulting in new feature class. Finally the changes are tabulated and maps are generated.

Table 8.1 Landuse/Landcover classification in study area

Sl.No.	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

5	Water bodies	River / Stream / Drain	River / Stream / Drain
		Canal	Canal
		Lakes / Ponds	Lakes / Ponds
		Reservoir / Tanks	Reservoir / Tanks

Source: Contemplated table for (IRS 1D –PAN + LISS-III /LISS IV Mx) from SIS-DP manual, Preparation of Geo Spatial Layers using High Resolution (Cartosat – 1 Pan + LISS-IV Mx) Orthorectified Satellite Imagery, NRSC(ISRO), DoS, GoI. Dec 2009

8.2 Analysis and results

The LU/LC classification is carried out for the year 2012 and 2021 by visual interpretation technique. This chapter briefs the results and outputs obtained from overlay analysis and change detection analysis

8.2.1 LU/LC change detection analysis outcomes

8.2.1.1.1 LULC change between 2012 and 2021 of Devadari: - 10 km buffer

The statistics generated from GIS analysis for the year 2012 to 2021 in 10 km buffer shows that Agricultural land is increased by 85.38 hectares with the difference of 1.06%, whereas built up area is increased by 457.47 hectares with the difference of 11.34%. Forest area is decreased by 469.68 hectares with a difference of 2.42%. Wasteland is decreased by 6.93% with 73.67 hectares. Water bodies are increased by 0.51 hectares with the difference of 0.08%. The detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3 classifications is tabulated in the Table 8.2.

Table 8.2 Detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3

Level	LULC Category	Area in hectares					
		2012	2018	2021	Difference 2012 and 2021	% difference	Remarks
Level-I	**Agricultural land**	**8005.83**	**8120.6**	**8091.20**	**85.38**	**1.06**	**Increase**
I	Agriculture plantation	194.81	200.0	200.67	**5.85**	**2.92**	**Increase**
II	Crop land	7811.02	7920.6	7890.54	**79.52**	**1.01**	**Increase**
Level-I	**Built up**	**3578.13**	**3960.4**	**4035.60**	**457.47**	**11.34**	**Increase**
I	Built up (Rural)	135.43	136.2	136.19	**0.77**	**0.56**	**Increase**
II	Core urban	166.49	167.2	167.25	**0.76**	**0.45**	**Increase**
III	Hamlets and dispersed household	47.00	62.1	62.45	**15.45**	**24.74**	**Increase**

IV	Mining / industrial	2627.14	2977.8	3052.48	**425.35**	**13.93**	**Increase**
V	Peri urban	47.77	55.2	55.43	**7.67**	**13.83**	**Increase**
VI	Transportation	316.29	316.3	316.29	**0.00**	**0.00**	**No Change**
VII	Village	238.03	245.5	245.50	**7.48**	**3.05**	**Increase**
Level-I	**Forest**	**19857.03**	**19441.3**	**19387.35**	**-469.68**	**-2.42**	**Decrease**
I	Forest	19844.83	19429.1	19375.15	**-469.68**	**-2.42**	**Decrease**
II	Forest plantation	12.20	12.2	12.20	**0.00**	**0.00**	**No Change**
Level-I	**Wastelands**	**1137.12**	**1065.0**	**1063.45**	**-73.67**	**-6.93**	**Decrease**
I	Barren rocky	127.32	127.3	127.32	**0.00**	**0.00**	**No Change**
II	Scrub land Dense	47.75	46.1	46.06	**-1.69**	**-3.67**	**Decrease**
III	Scrub land Open	957.13	886.7	885.15	**-71.98**	**-8.13**	**Decrease**
IV	Waterlogged	4.93	4.9	4.93	**0.00**	**0.00**	**No Change**
Level-I	**Water bodies**	**640.77**	**631.6**	**641.29**	**0.51**	**0.08**	**Increase**
I	Canal	6.31	6.3	6.31	**0.00**	**0.00**	**No Change**
II	Lakes / Ponds	4.02	4.5	4.67	**0.65**	**13.88**	**Increase**
III	Reservoir / Tanks	323.85	314.2	323.71	**-0.14**	**-0.04**	**Decrease**
IV	River / Stream / Drain	306.60	306.6	306.60	**0.00**	**0.00**	**No Change**
Grand Total		**33218.89**	**33218.9**	**33218.89**			

The LU/LC map of level 3 classifications of 2012, 2018 and 2021 are shown in the Figure 8.1, 8.2 and 8.3 respectively.

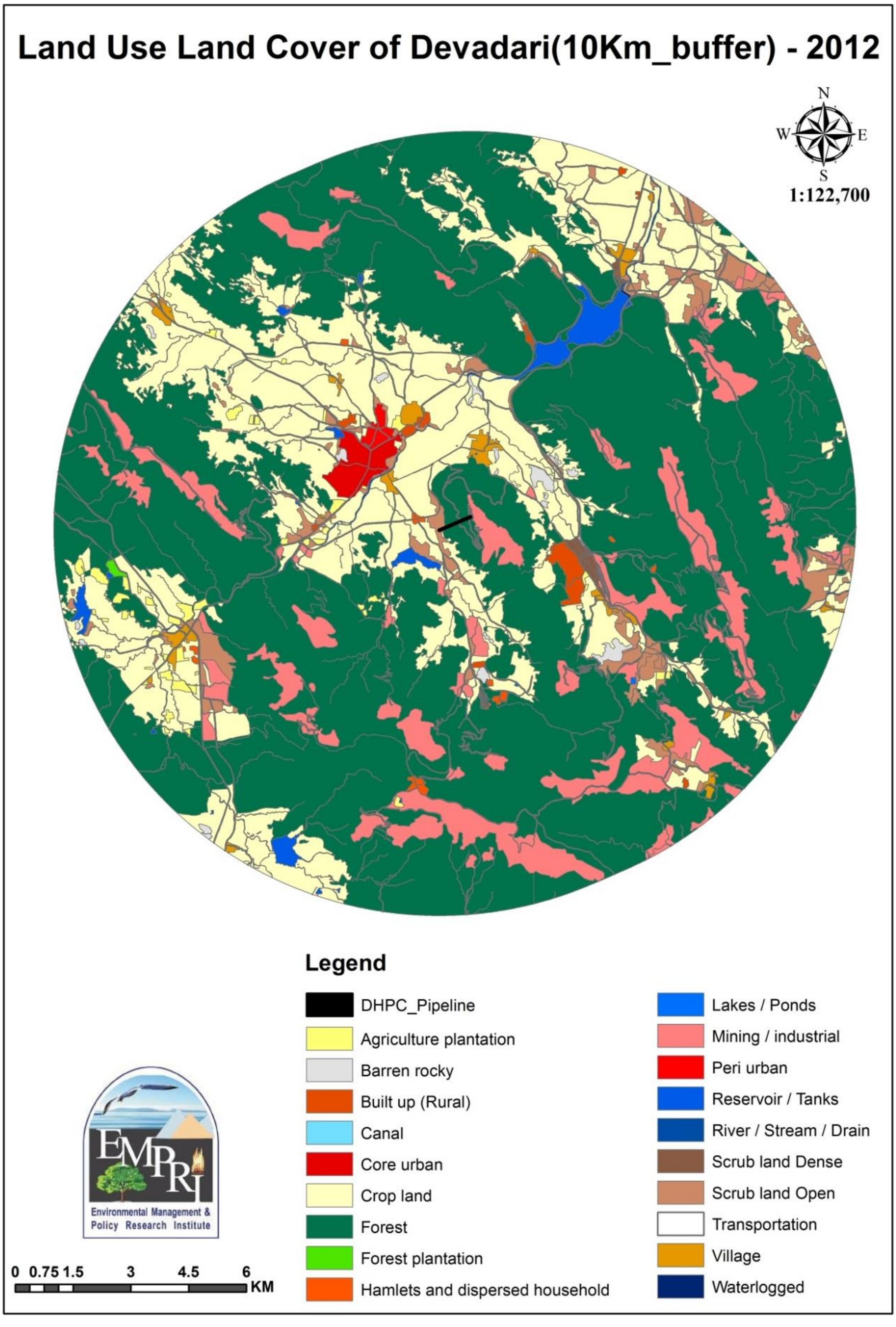


Figure 8.1 Land Use/ Land Cover – 2012 for 10 Km buffer

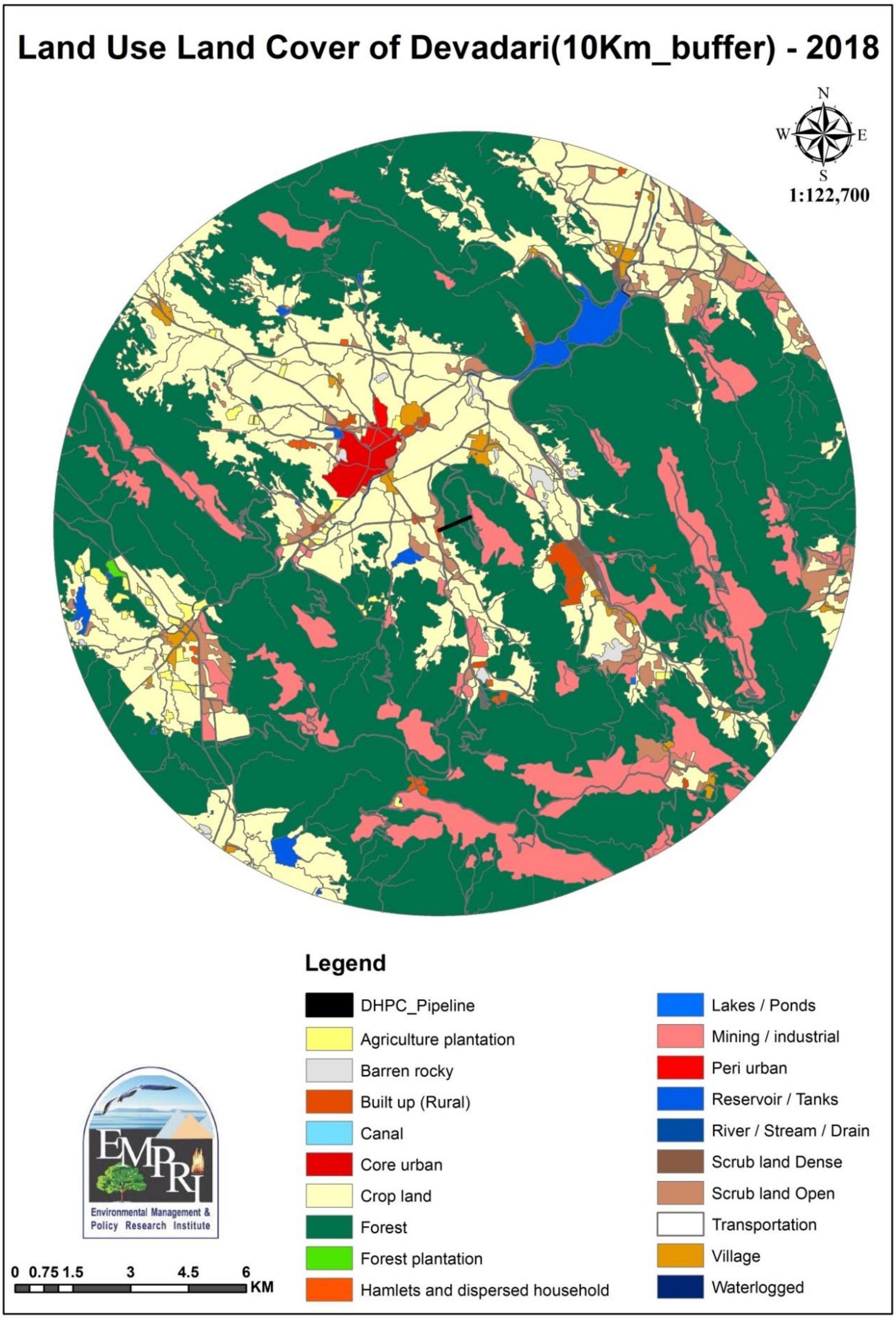


Figure 8.2 Land Use/ Land Cover – 2018 for 10 Km buffer

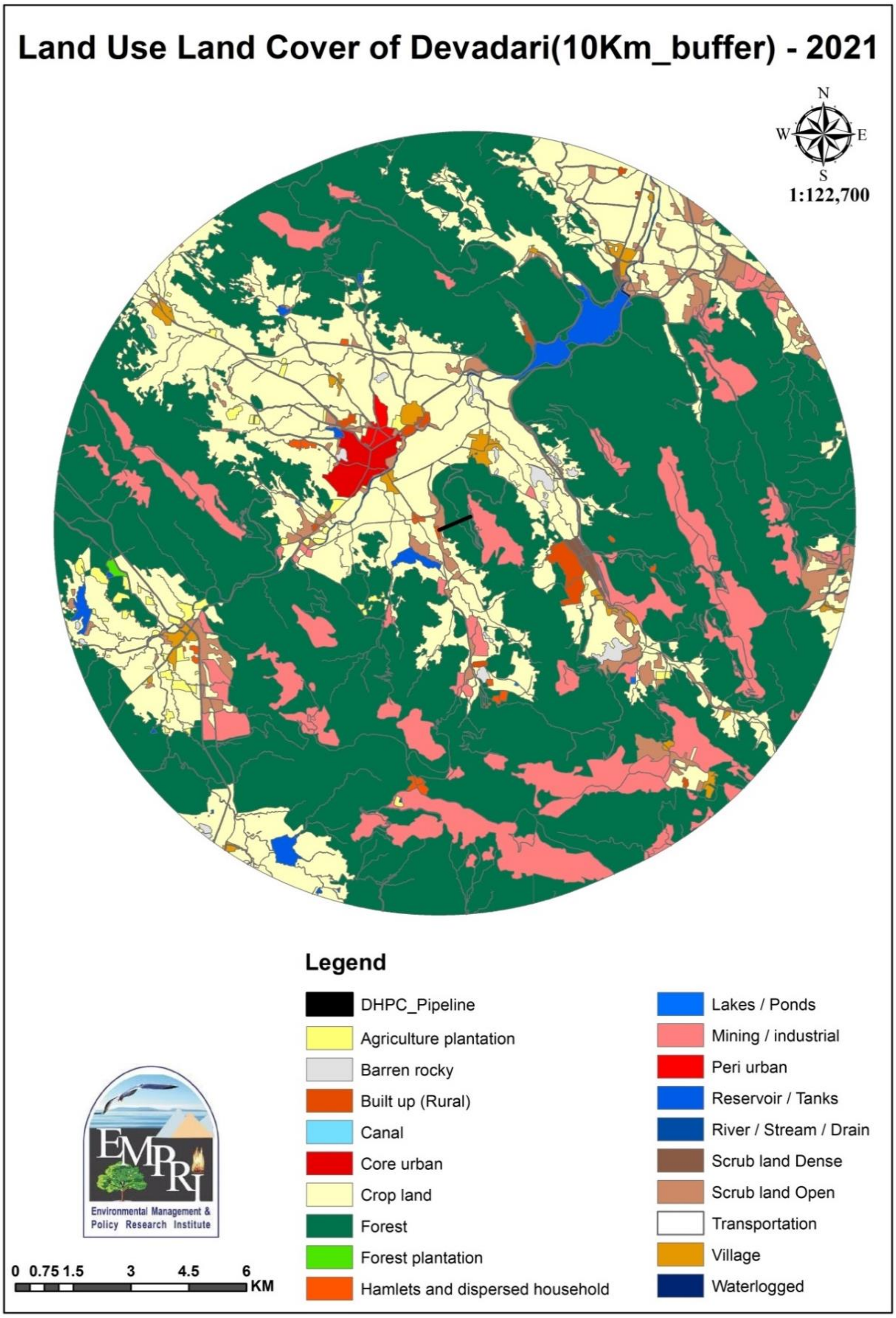


Figure 8.3 Land Use/ Land Cover – 2021 for 10 Km buffer

8.2.1.1.2 LULC change between 2012 and 2021 of Devadari: - 2 km buffer

The statistics generated from GIS analysis for the year 2012 to 2021 in 2 km buffer, shows that Agricultural land is increased by 5.18 hectares with the difference of 0.75%, whereas built up area is increased by 11.49 hectares with the difference of 5.63%. Forest area is decreased by 10 hectares with a difference of 1.65%. Wasteland is decreased by 7.96% with 6.52 hectares. Water bodies are increased by 0.14 hectares with the difference of 0.38%. The detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3 classifications are tabulated in the Table 8.3.

Table 8.3 Detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3

Level	LULC Category	Area in hectares					
		2012	2018	2021	difference 2012 and 2021	% difference	Remarks
Level-I	Agricultural land	685.46	699.047	690.64	5.18	0.75	Increase
I	Crop land	685.46	699.047	690.64	5.18	0.75	Increase
Level-I	Built up	192.64	195.834	204.13	11.49	5.63	Increase
I	Hamlets and dispersed household	6.04	9.230	9.23	3.19	34.58	Increase
II	Mining / industrial	119.11	119.106	127.40	8.29	6.51	Increase
III	Transportation	21.87	21.874	21.87	0.00	0.00	No Change
IV	Village	45.62	45.624	45.62	0.00	0.00	No Change
Level-I	Forest	615.71	615.420	605.71	-10.00	-1.65	Decrease
I	Forest	615.71	615.420	605.71	-10.00	-1.65	Decrease
Level-I	Wastelands	88.51	81.702	81.98	-6.52	-7.96	Decrease
I	Barren rocky	12.45	12.446	12.45	0.00	0.00	No Change
II	Scrub land Open	76.06	69.256	69.54	-6.52	-9.38	Decrease
Level-I	Water bodies	35.90	26.215	35.76	-0.14	-0.38	Decrease
I	Lakes / Ponds	0.32	0.315	0.32	0.00	0.00	No Change
II	Reservoir / Tanks	30.66	20.977	30.52	-0.14	-0.45	Decrease
III	River / Stream / Drain	4.92	4.923	4.92	0.00	0.00	No Change
Grand Total		1618.22	1618.218	1618.22			

Graphical represenataion of the LU/LC map of level 3 classifications of 2012, 2018 and 2021 are shown in the Figure 8.4, 8.5 and 8.6 respectively.

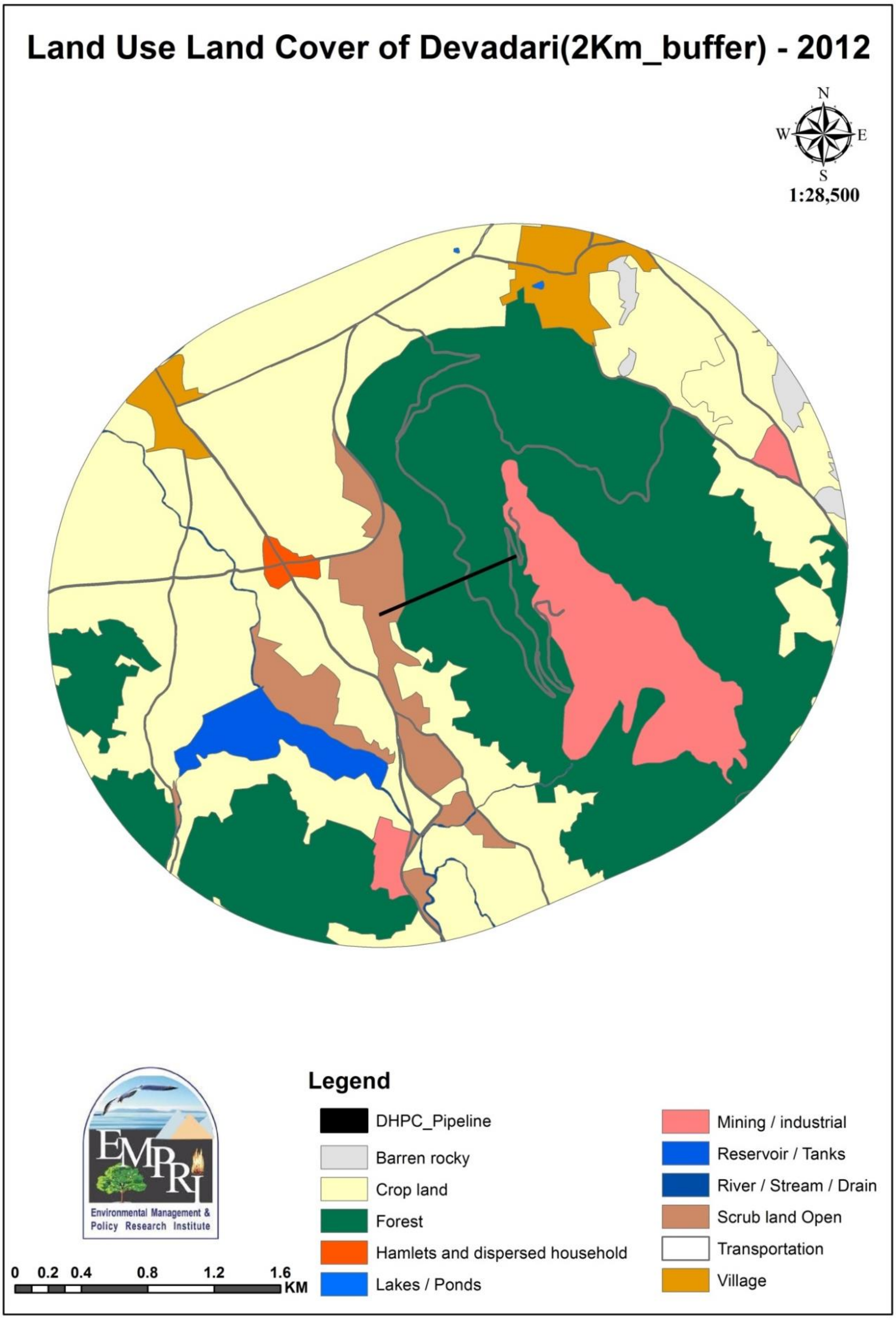


Figure 8.4 Land Use/ Land Cover – 2012 for 2 Km buffer

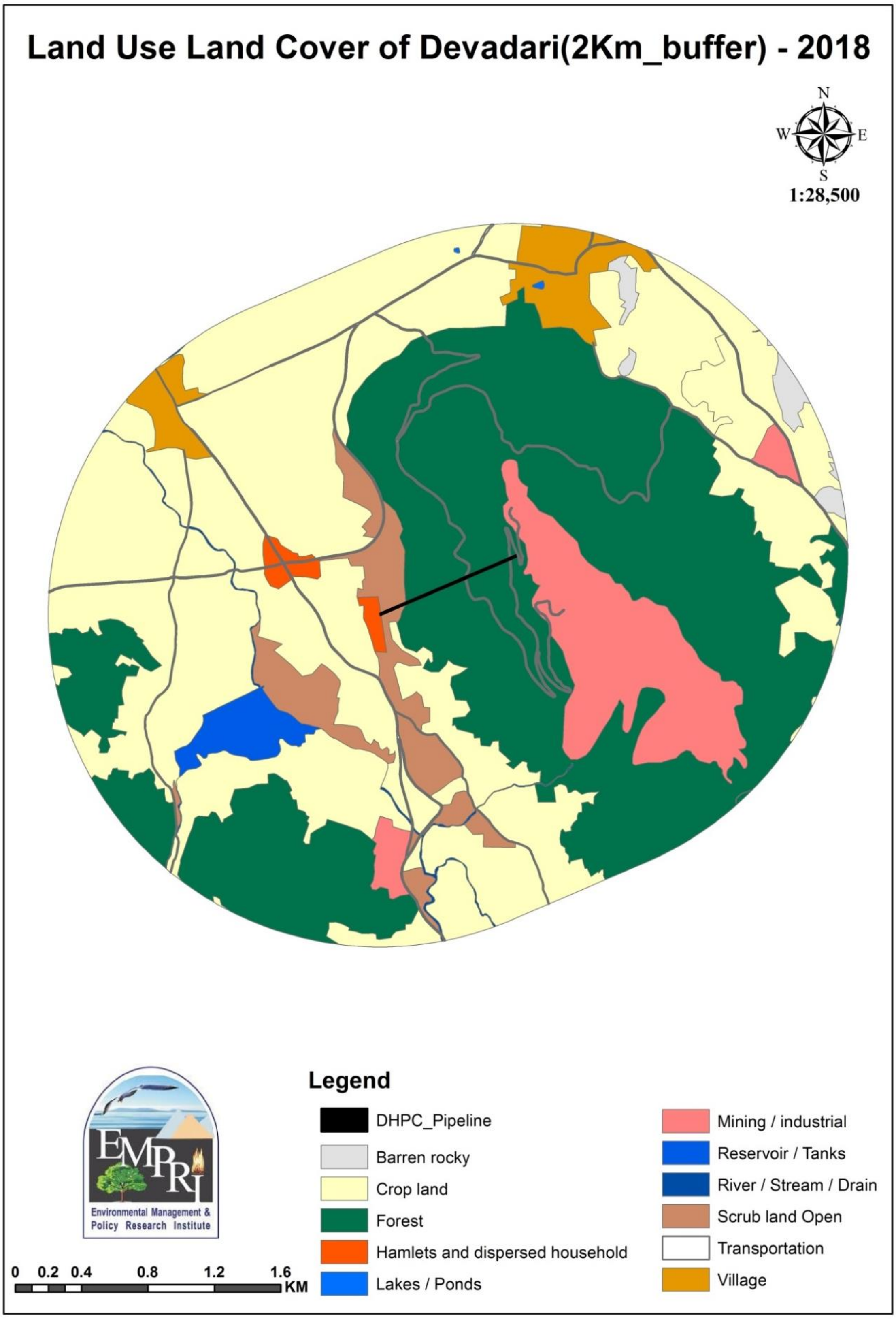


Figure 8.5 Land Use/ Land Cover – 2018 for 2 Km buffer

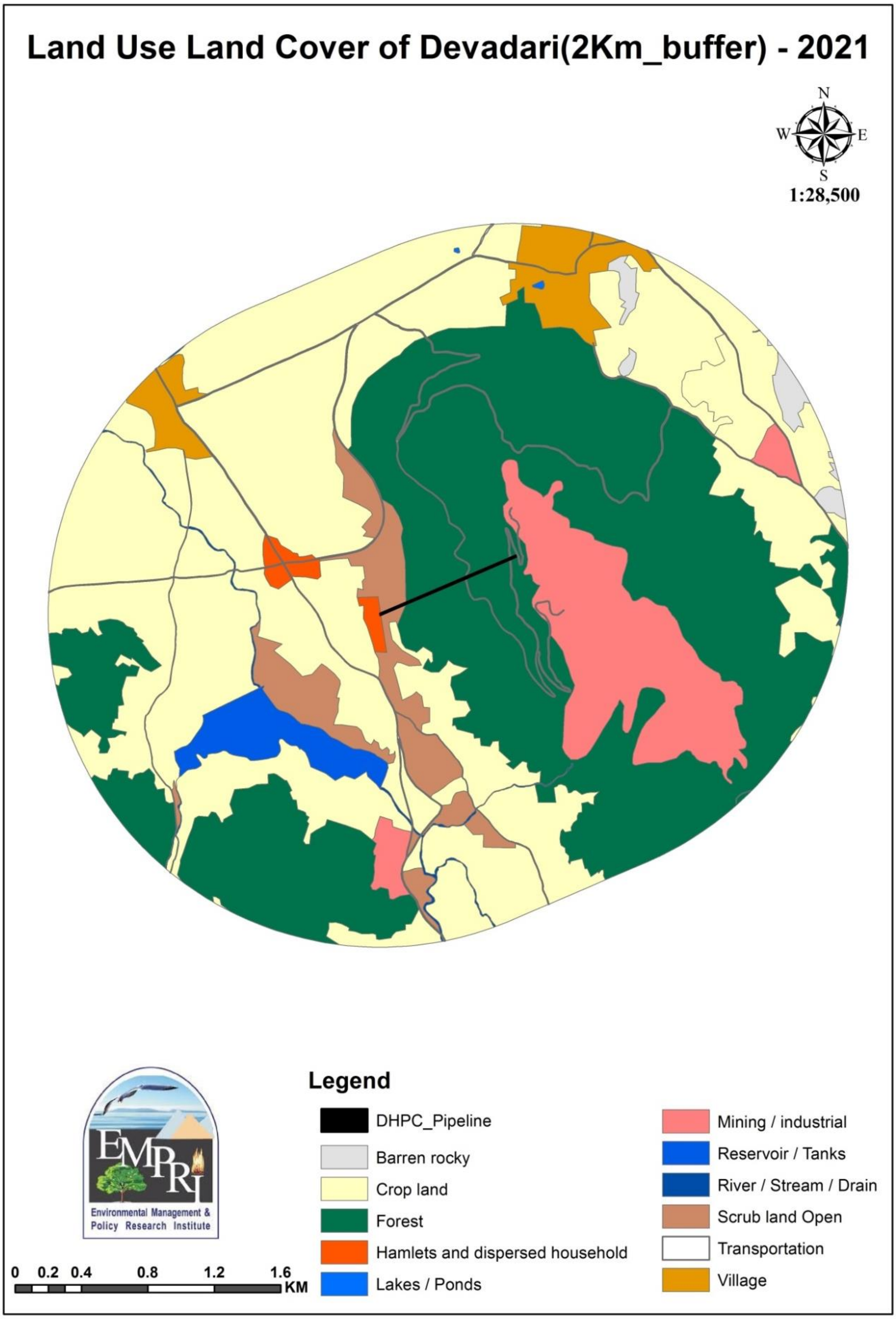


Figure 8.6 Land Use/ Land Cover – 2021 for 2 Km buffer

8.2.1.2 LULC change between 2012 and 2021 of Rama: - 10 km buffer

The statistics generated from GIS analysis for the year 2012 to 2021 in 10 km buffer, shows that Agricultural land is increased by 181.10 hectares with the difference of 1.49%, whereas built up area is increased by 160.35 hectares with the difference of 4.82%. Forest area is decreased by 282.80 hectares with a difference of 1.06%. Wasteland is decreased by 4.33% with 70.52 hectares. Water bodies are increased by 11.88 hectares with the difference of 1.04%. The detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3 classifications are tabulated in the Table 8.4.

Table 8.4 Detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3

Level	LULC Category	Area in hectares					
		2012	2018	2021	difference 2012 and 2021	% difference	Remarks
Level-I	Agricultural land	11940.95	12162.16	12122.06	181.10	1.49	Increase
I	Agriculture plantation	203.19	209.86	211.62	8.42	3.98	Increase
II	Crop land	11737.76	11952.30	11910.44	172.68	1.45	Increase
Level-I	Built up	3169.73	3245.56	3330.07	160.35	4.82	Increase
I	Built up (Rural)	144.73	146.12	150.81	6.08	4.03	Increase
II	Core urban	166.49	167.25	167.25	0.76	0.45	Increase
III	Hamlets and dispersed household	19.22	34.99	40.04	20.82	52.00	Increase
IV	Mining / industrial	2153.89	2217.52	2290.12	136.23	5.95	Increase
V	Peri urban	47.77	55.20	55.43	7.67	13.83	Increase
VI	Transportation	323.12	323.12	323.12	0.00	0.00	No Change
VII	Village	294.75	301.37	303.30	8.55	2.82	Increase
Level-I	Forest	26957.85	26731.65	26675.05	-282.80	-1.06	Decrease
I	Forest	26945.65	26719.45	26662.85	-282.80	-1.06	Decrease
II	Forest plantation	12.20	12.20	12.20	0.00	0.00	No Change
Level-I	Wastelands	1700.24	1647.76	1629.72	-70.52	-4.33	Decrease
I	Barren rocky	537.55	537.30	536.55	-1.00	-0.19	Decrease
II	Salt affected	37.80	36.57	31.46	-6.33	-20.13	Decrease
III	Sandy areas	0.88	0.88	0.88	0.00	0.00	No Change
IV	Scrub land Dense	40.67	38.98	38.98	-1.69	-4.34	Decrease
V	Scrub land Open	1079.58	1030.68	1018.51	-61.07	-6.00	Decrease

VI	Waterlogged	3.77	3.34	3.34	-0.43	-12.88	Decrease
Level-I	Water bodies	1133.89	1115.54	1145.77	11.88	1.04	Increase
I	Canal	5.61	5.61	5.61	0.00	0.00	No Change
II	Lakes / Ponds	7.39	21.65	24.12	16.73	69.38	Increase
III	Reservoir / Tanks	756.12	723.50	751.26	-4.86	-0.65	Decrease
IV	River / Stream / Drain	364.78	364.78	364.78	0.00	0.00	No Change
Grand Total		44902.66	44902.66	44902.66			

The LU/LC map of level 3 classifications of 2012, 2018 and 2021 are shown in the Figure 8.7, 8.8 and 8.9 respectively for 10 km buffer area.

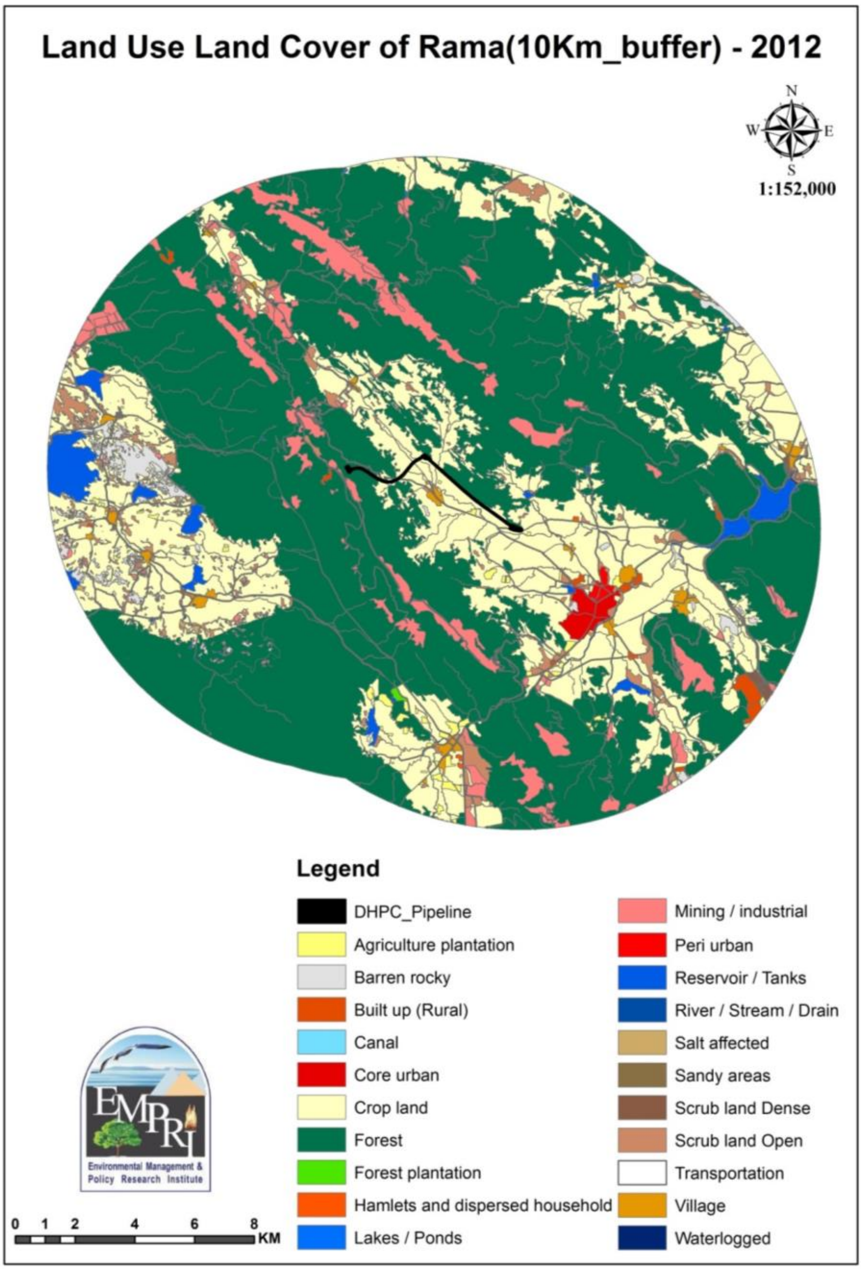


Figure 8.7 LU/LC map of level 3 classifications of 2012 – 10km buffer

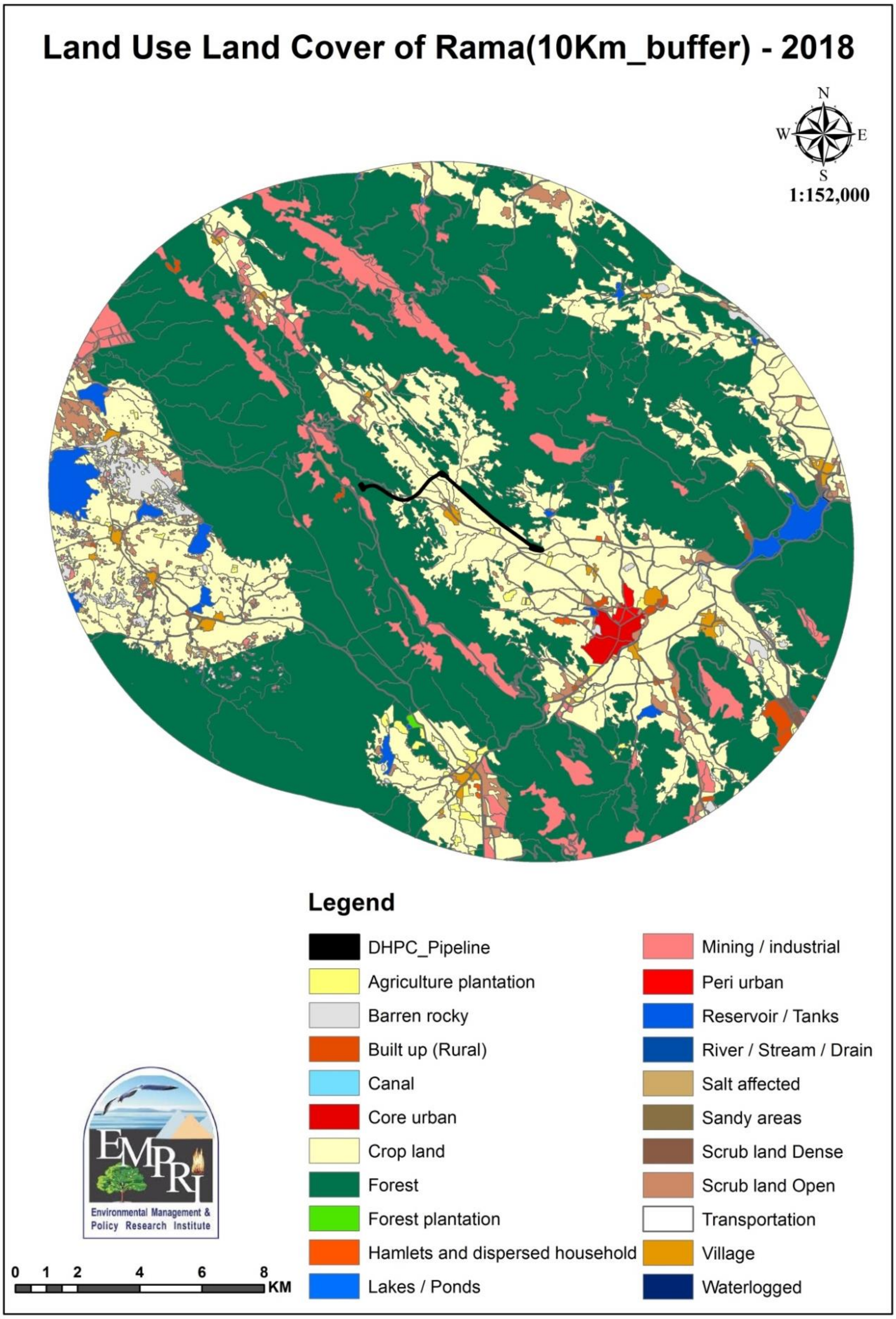


Figure 8.8 LU/LC map of level 3 classifications of 2018 – 10km buffer

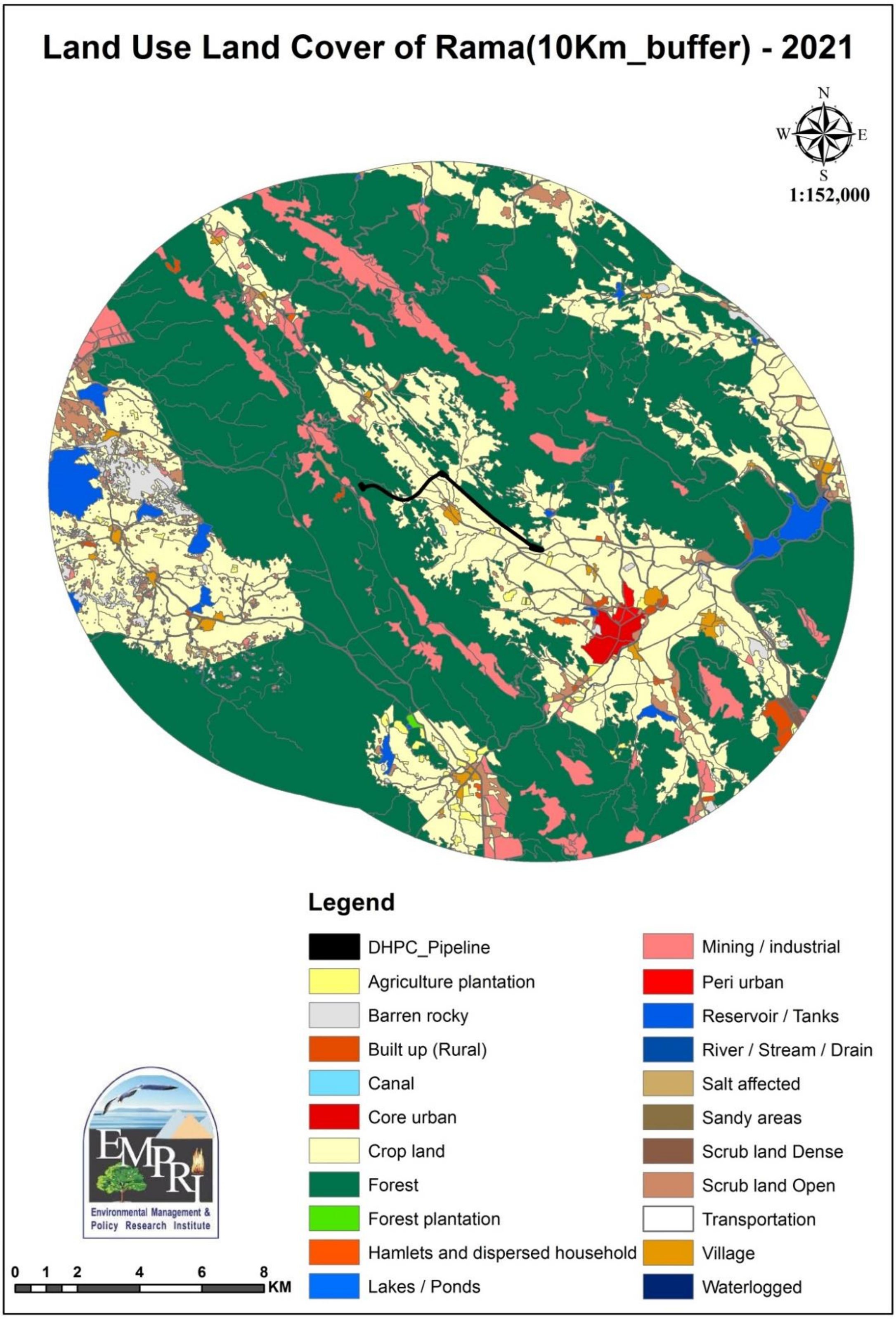


Figure 8.9 LU/LC map of level 3 classifications of 2021 – 10km buffer

8.2.1.2.1 LULC change between 2012 and 2021 of Rama: - 2 km buffer

The statistics generated from GIS analysis for the year 2012 to 2021 in 2 km buffer, shows that Agricultural land is increased by 50.87 hectares with a difference of 2.50%, whereas built up area is increased by 1.41 hectares with the difference of 0.83%. Forest area is decreased by 52.24 hectares with a difference of 2.87%. Wasteland is decreased by 0.1% with 0.04 hectares. There are no changes in water bodies. The detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3 classifications are tabulated in the Table 8.5.

Table 8.5 Detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3

Level	LULC Category	Area in hectares					
		2012	2018	2021	difference 2012 and 2021	% difference	Remarks
Level-I	Agricultural land	1985.03	2031.64	2035.90	50.87	2.50	Increase
I	Agriculture plantation	24.40	28.89	28.89	4.49	15.54	Increase
II	Crop land	1960.63	2002.74	2007.01	46.38	2.31	Increase
Level-I	Built up	168.16	169.57	169.57	1.41	0.83	Increase
I	Built up (Rural)	7.76	7.76	7.76	0.00	0.00	No Change
II	Hamlets and dispersed household	2.95	2.95	2.95	0.00	0.00	No Change
III	Mining / industrial	93.86	93.86	93.86	0.00	0.00	No Change
IV	Transportation	32.55	32.55	32.55	0.00	0.00	No Change
V	Village	31.04	32.45	32.45	1.41	4.34	Increase
Level-I	Forest	1873.50	1825.53	1821.26	-52.24	-2.87	Decrease
I	Forest	1873.50	1825.53	1821.26	-52.24	-2.87	Decrease
Level-I	Wastelands	39.63	39.60	39.60	-0.04	-0.10	Decrease
I	Barren rocky	3.60	3.60	3.60	0.00	0.00	No Change
II	Scrub land Dense	0.48	0.48	0.48	0.00	0.00	No Change
III	Scrub land Open	35.55	35.52	35.52	-0.04	-0.11	Decrease
Level-I	Water bodies	42.55	42.55	42.55	0.00	0.00	No Change
I	Reservoir / Tanks	7.47	7.47	7.47	0.00	0.00	No Change
II	River / Stream / Drain	35.08	35.08	35.08	0.00	0.00	No Change
Grand Total		4108.88	4108.88	4108.88			

Graphical representation of the LU/LC map of level 3 classifications of 2012, 2018 and 2021 are shown in the Figure 8.10, 8.11 and 8.12 respectively for 2 km buffer area.

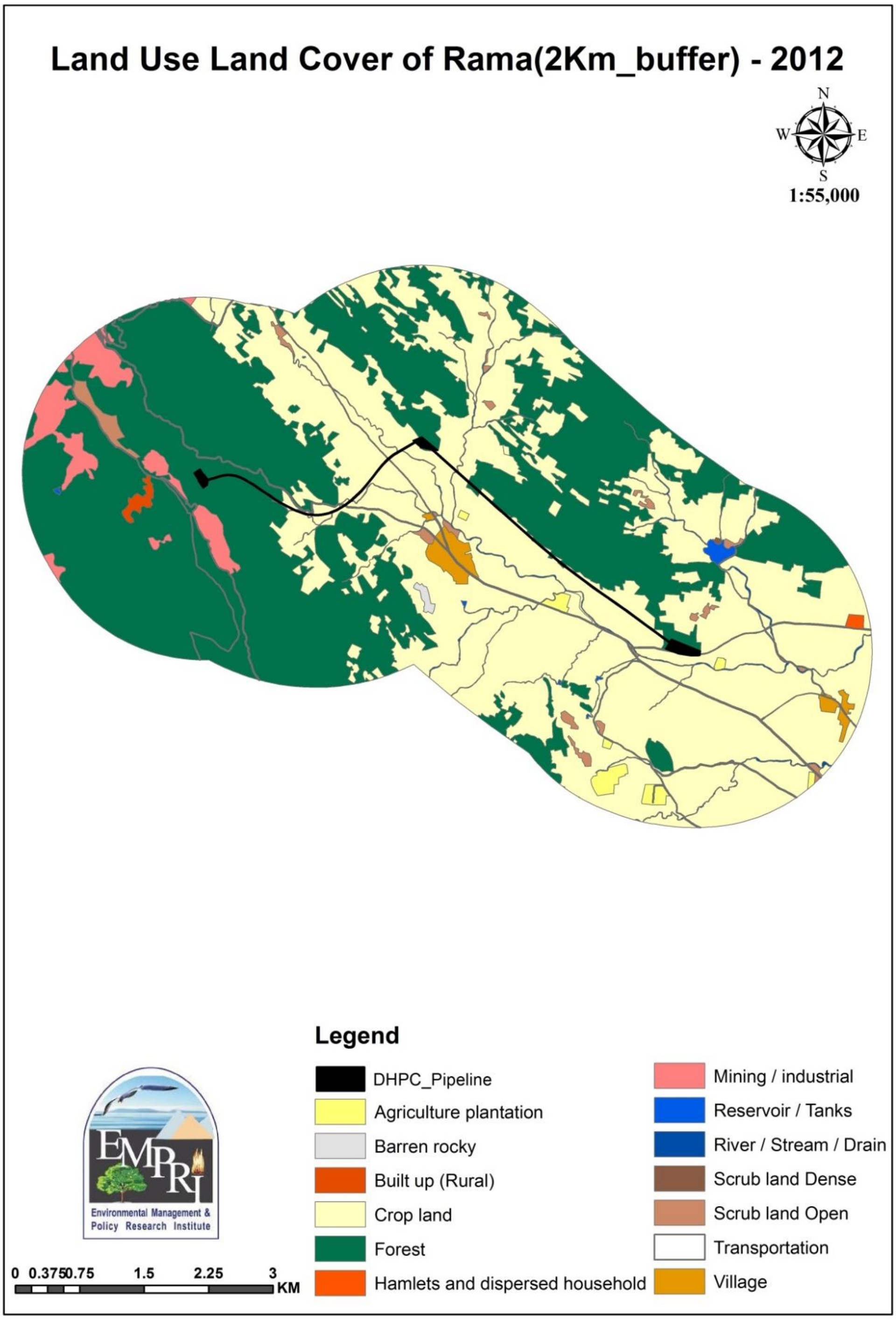


Figure 8.10 Graphical representation of the LU/LC map of level 3 classifications of 2012 – 2km buffer

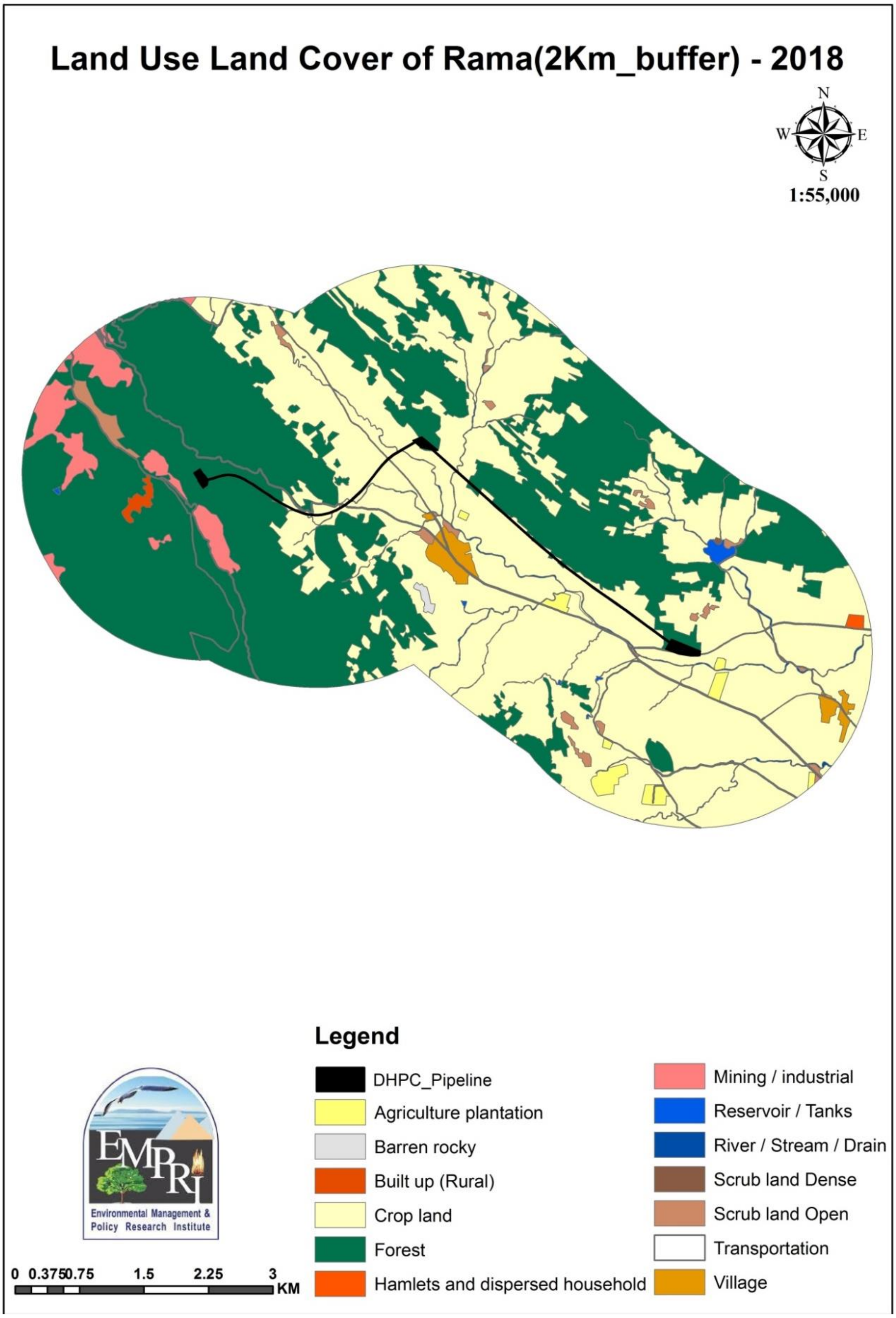


Figure 8.11 Graphical representation of the LU/LC map of level 3 classifications of 2018 – 2km buffer

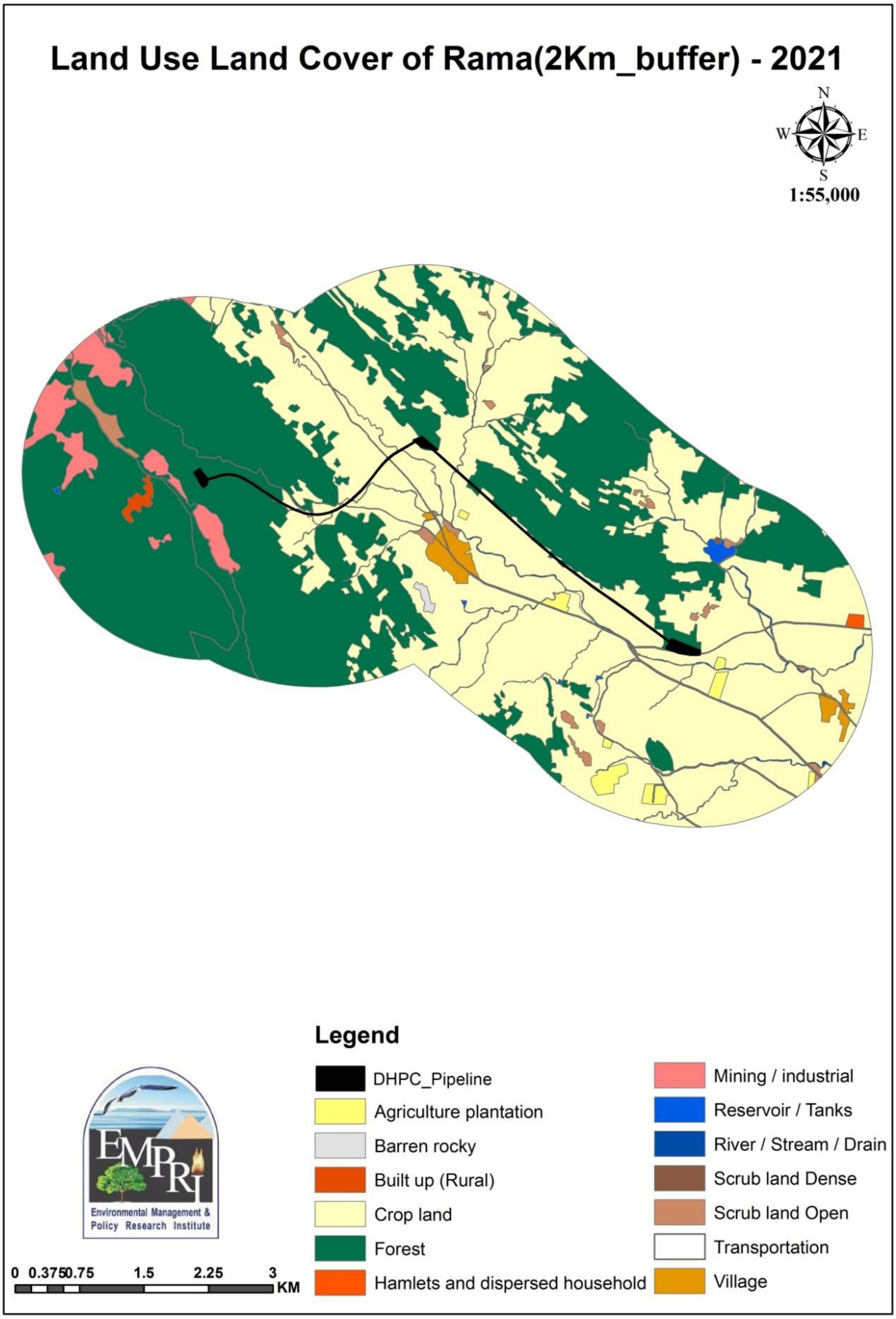


Figure 8.12 Graphical representation of the LU/LC map of level 3 classifications of 2021 – 2km buffer

8.2.1.2.2 LULC change between 2012 and 2021 of Tunga & Bhadra 10 km buffer

The statistics generated from GIS analysis for the year 2012 to 2021 in 10 km buffer, shows that Agricultural land is increased by 129.92 hectares with the difference of 1.06%, whereas built up area is increased by 275.22 hectares with the difference of 5.10%. Forest area is decreased by 245.45 hectares with a difference of 1.46%. Wasteland is decreased by 7.50% with 292.08 hectares. Water bodies are increased by 132.39 hectares with the difference of 10.71%. The detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3 classifications are tabulated in the Table 8.6.

Table 8.6 Detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3

Level	LULC Category	Area in hectares					
		2012	2018	2021	difference 2012 and 2021	% difference	Remarks
Level-I	**Agricultural land**	**12134.65**	**12215.50**	**12264.56**	**129.92**	**1.06**	**Increase**
I	Agriculture plantation	34.13	34.21	34.30	**0.17**	**0.49**	**Increase**
II	Crop land	12100.52	12181.29	12230.27	**129.75**	**1.06**	**Increase**
Level-I	**Built up**	**5118.28**	**5341.72**	**5393.50**	**275.22**	**5.10**	**Increase**
I	Built up (Rural)	129.43	169.26	169.27	**39.84**	**23.54**	**Increase**
II	Built up (Urban)	44.72	44.72	44.72	**0.00**	**0.00**	**No Change**
III	Core urban	177.34	178.10	178.10	**0.76**	**0.43**	**Increase**
IV	Hamlets and dispersed household	57.67	83.14	90.81	**33.14**	**36.49**	**Increase**
V	Mining / industrial	3859.83	3997.90	4041.77	**181.94**	**4.50**	**Increase**
VI	Peri urban	47.77	55.20	55.43	**7.67**	**13.83**	**Increase**
VII	Transportation	382.27	382.27	382.27	**0.00**	**0.00**	**No Change**
VIII	Village	419.25	431.13	431.13	**11.88**	**2.76**	**Increase**
Level-I	**Forest**	**17009.73**	**16834.99**	**16764.29**	**-245.45**	**-1.46**	**Decrease**
I	Forest	16983.69	16808.95	16738.24	**-245.45**	**-1.47**	**Decrease**
II	Forest plantation	26.05	26.05	26.05	**0.00**	**0.00**	**No Change**
Level-I	**Wastelands**	**4185.79**	**3934.52**	**3893.71**	**-292.08**	**-7.50**	**Decrease**
I	Barren rocky	500.35	499.20	499.20	**-1.16**	**-0.23**	**Decrease**
II	Gullied / ravenous	27.17	8.45	8.45	**-18.72**	**-221.61**	**Decrease**
III	Salt affected	62.38	87.19	87.14	**24.76**	**28.41**	**Increase**
IV	Sandy areas	14.93	14.93	14.93	**0.00**	**0.00**	**No Change**

V	Scrub land Dense	50.70	49.01	49.01	**-1.69**	**-3.45**	**Decrease**
VI	Scrub land Open	3313.67	3059.16	3016.75	**-296.92**	**-9.84**	**Decrease**
VII	Waterlogged	216.59	216.59	216.59	**0.00**	**0.00**	**No Change**
Level-I	**Water bodies**	**1103.83**	**1225.54**	**1236.22**	**132.39**	**10.71**	**Increase**
I	Canal	24.76	24.76	24.76	**0.00**	**0.00**	**No Change**
II	Lakes / Ponds	35.97	37.19	38.35	**2.38**	**6.20**	**Increase**
III	Reservoir / Tanks	652.22	772.72	782.26	**130.04**	**16.62**	**Increase**
IV	River / Stream / Drain	390.87	390.87	390.85	**-0.02**	**-0.01**	**Decrease**
Grand Total		**39552.27**	**39552.27**	**39552.27**			

The LU/LC map of level 3 classifications of 2012 2018 and 2021 are shown in the Figure 8.13, 8.14 and 8.15 respectively.

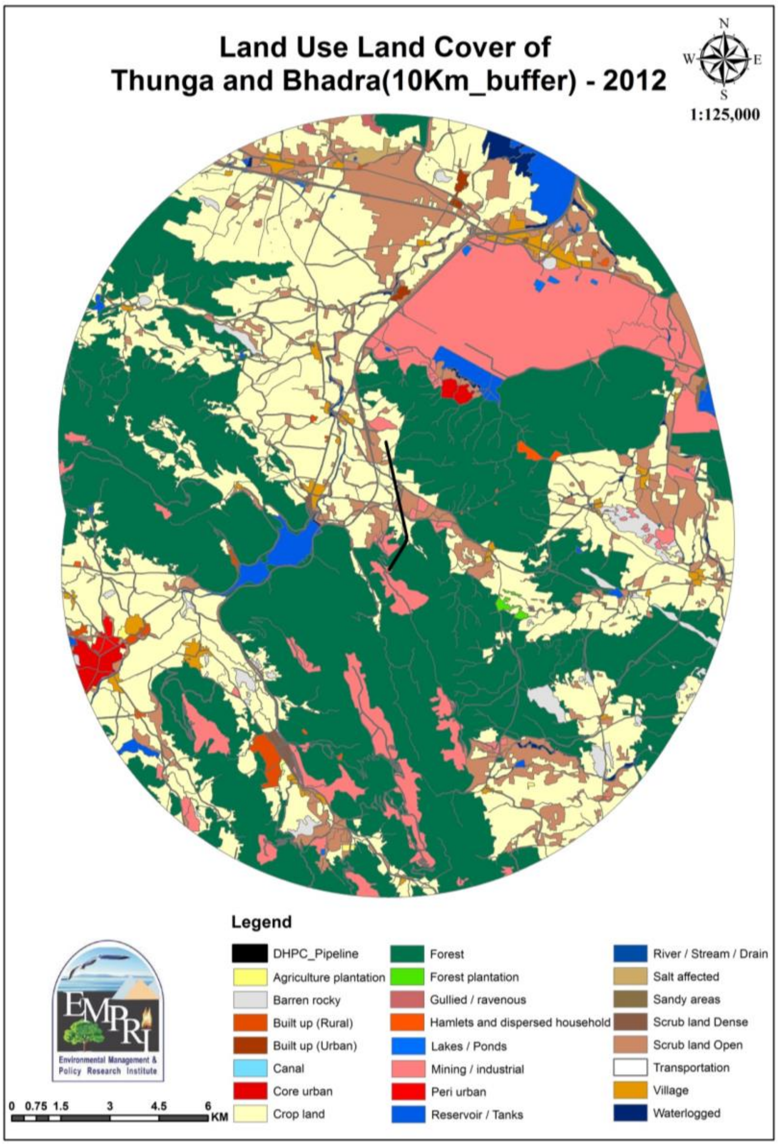


Figure 8.13 LU/LC map of level 3 classifications of 2012 - 10 km buffer

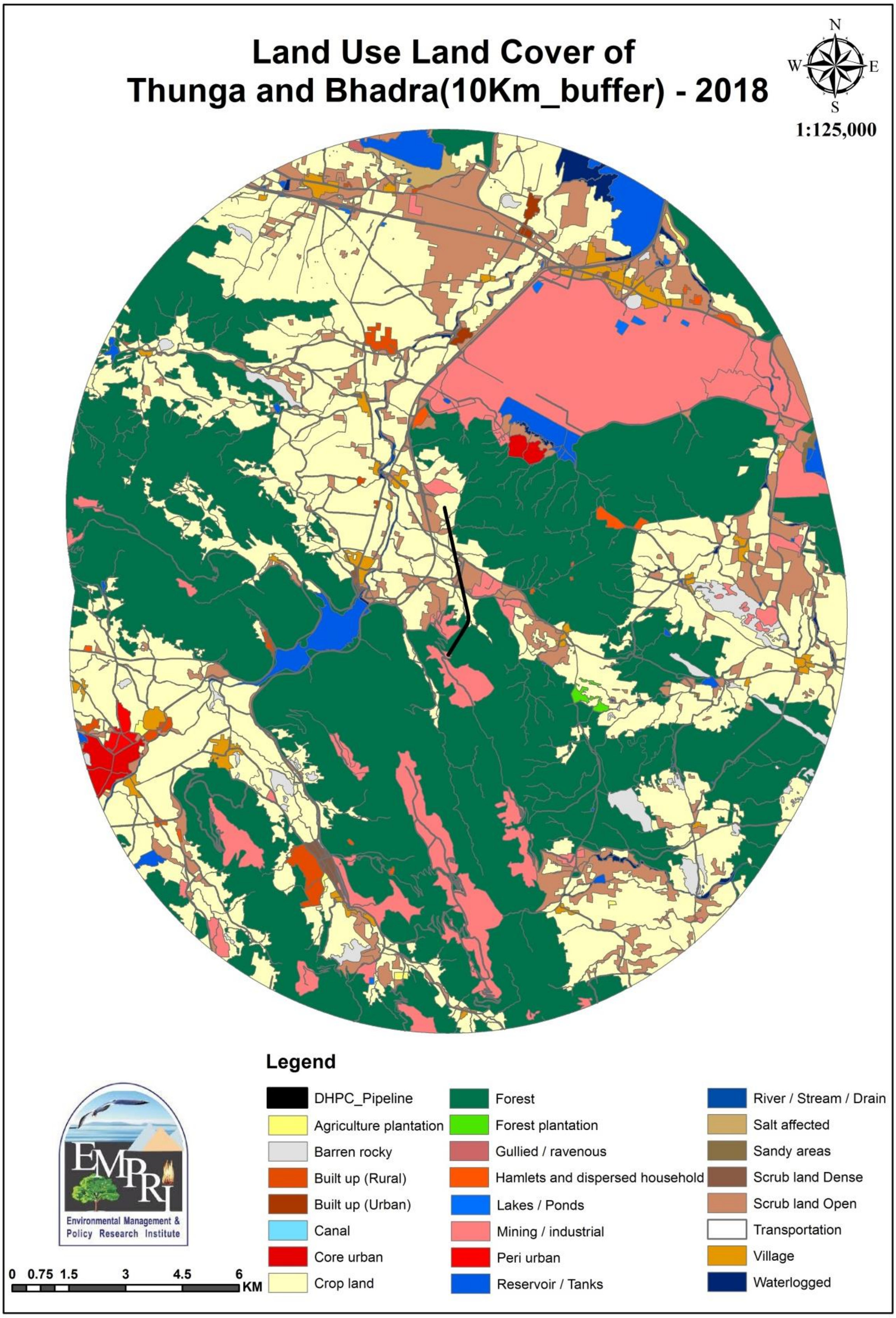


Figure 8.14 LU/LC map of level 3 classifications of 2018 - 10 km buffer

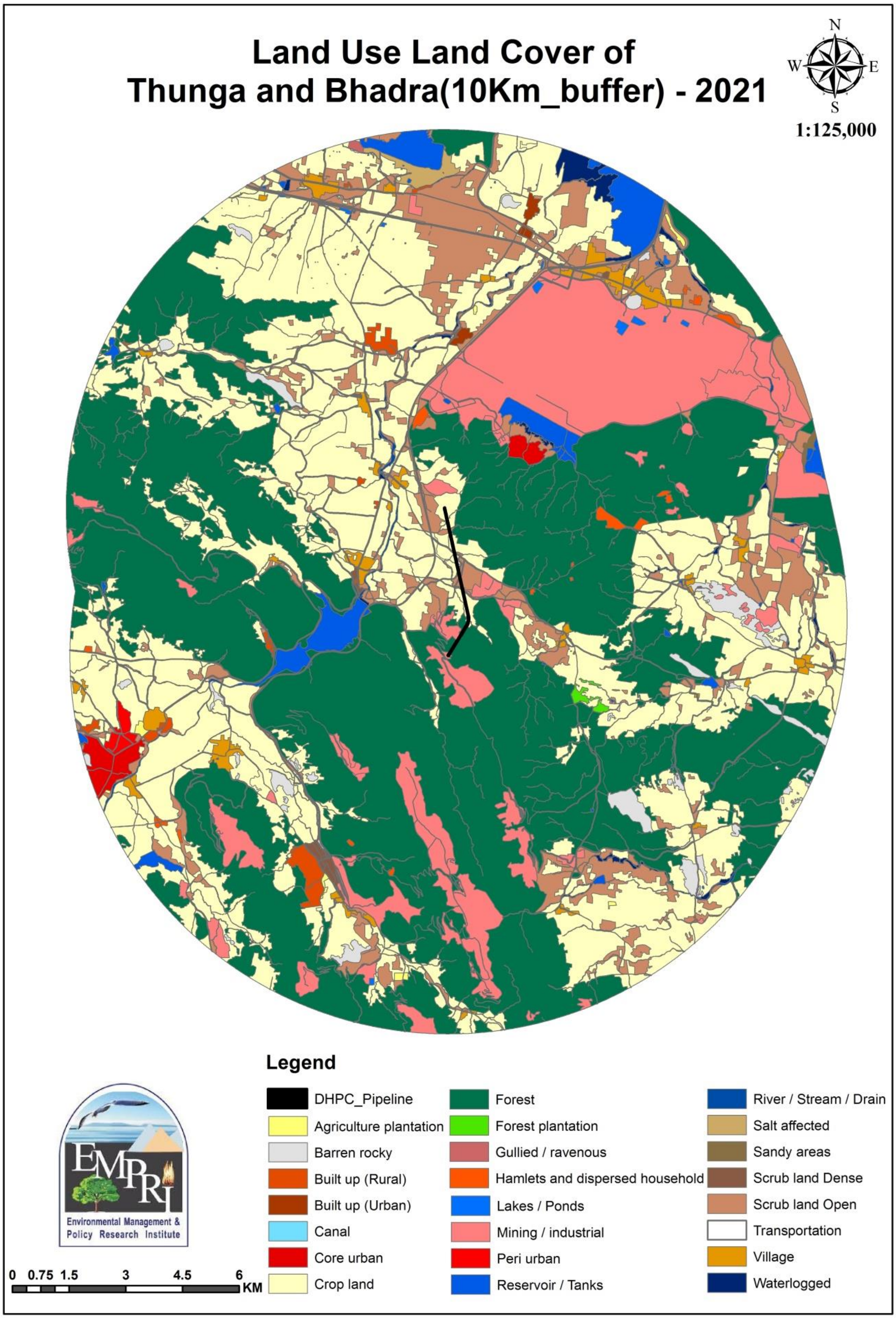


Figure 8.15 LU/LC map of level 3 classifications of 2021 - 10 km buffer

8.2.1.2.3 LULC change between 2012 and 2021 of Tunga & Bhadra 2 km buffer

The statistics generated from GIS analysis for the year 2012 to 2021 in 2 km, shows that Agricultural land is increased by 15.49 hectares with the difference of 1.84%, whereas built up area is increased by 45.02 hectares with a difference of 15.90%. Forest area is decreased by 39.31 hectares with a difference of 2.69%. Wasteland is decreased by 7.66% with 21.19 hectares. There are no changes in water bodies. The detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3 classifications are tabulated in the Table 8.7.

Table 8.7 Detailed analysis LU/LC changes from 2012 to 2021 of level 1 and level 3

Level	LULC Category	Area in hectares					
		2012	2018	2021	difference 2012 and 2021	% difference	Remarks
Level-I	Agricultural land	825.03	837.28	840.52	15.49	1.84	Increase
I	Crop land	825.03	837.28	840.52	15.49	1.84	Increase
Level-I	Built up	238.03	280.08	283.05	45.02	15.90	Increase
I	Built up (Rural)	1.97	1.97	1.97	0.00	0.00	No Change
II	Hamlets and dispersed household	0.50	1.47	1.47	0.97	66.05	Increase
III	Mining / industrial	190.75	226.70	229.67	38.92	16.95	Increase
IV	Transportation	33.38	33.38	33.38	0.00	0.00	No Change
V	Village	11.44	16.56	16.56	5.12	30.94	Increase
Level-I	Forest	1501.51	1466.58	1462.20	-39.31	-2.69	Decrease
I	Forest	1501.51	1466.58	1462.20	-39.31	-2.69	Decrease
Level-I	Wastelands	297.87	278.50	276.68	-21.19	-7.66	Decrease
I	Scrub land Open	295.74	276.37	274.54	-21.19	-7.72	Decrease
II	Waterlogged	2.14	2.14	2.14	0.00	0.00	No Change
Level-I	Water bodies	44.92	44.92	44.92	0.00	0.00	No Change
I	Canal	1.98	1.98	1.98	0.00	0.00	No Change
II	Reservoir / Tanks	0.25	0.25	0.25	0.00	0.00	No Change
III	River / Stream / Drain	42.69	42.69	42.69	0.00	0.00	No Change
Grand Total		2907.36	2907.36	2907.36			

Graphical representation of LU/LC map of level 3 classifications of 2012 and 2021 are shown in the Figures 8.16, 8.17 and 8.18 respectively.

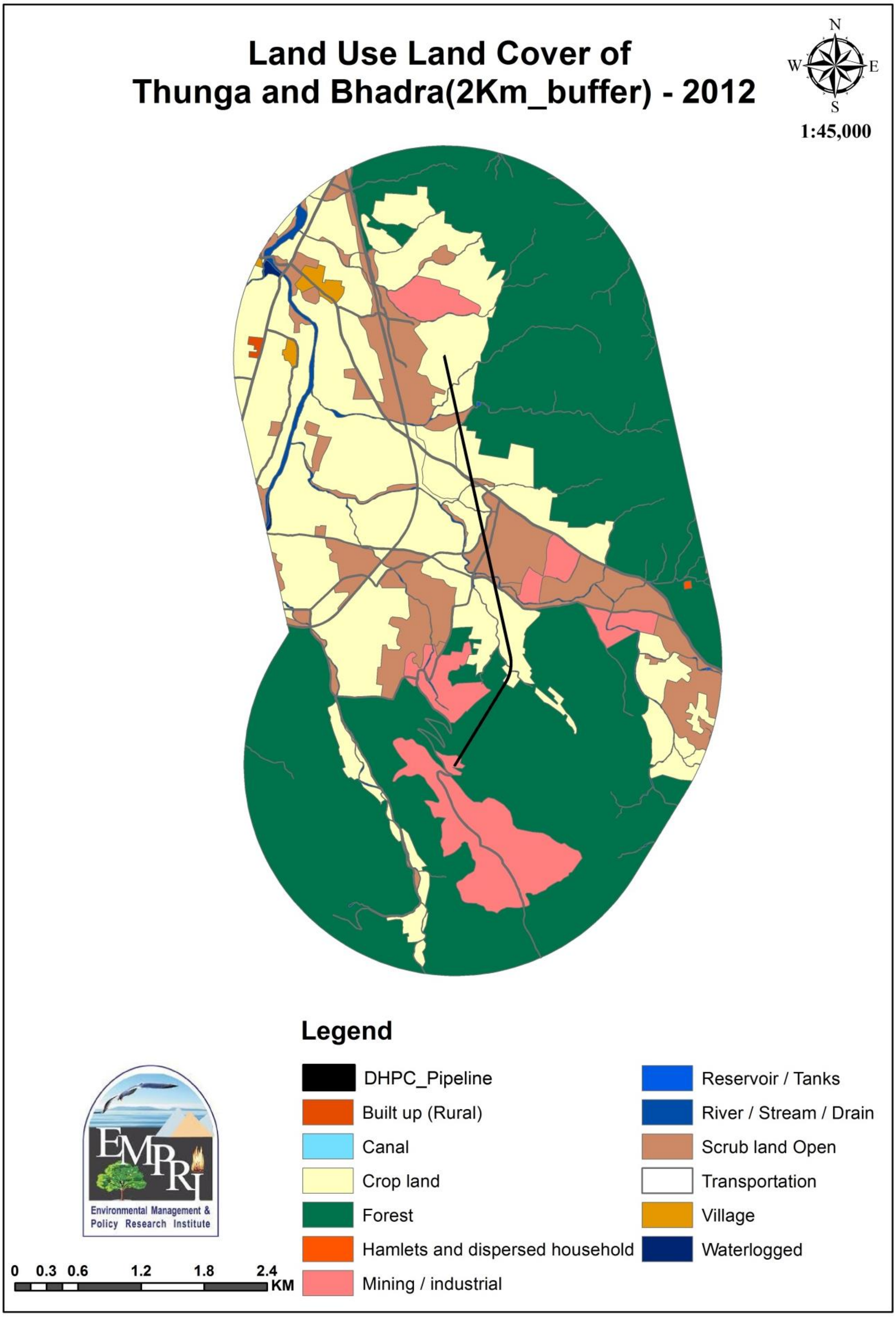


Figure 8.16 Land Use/ Land Cover – 2012 for 2 Km buffer

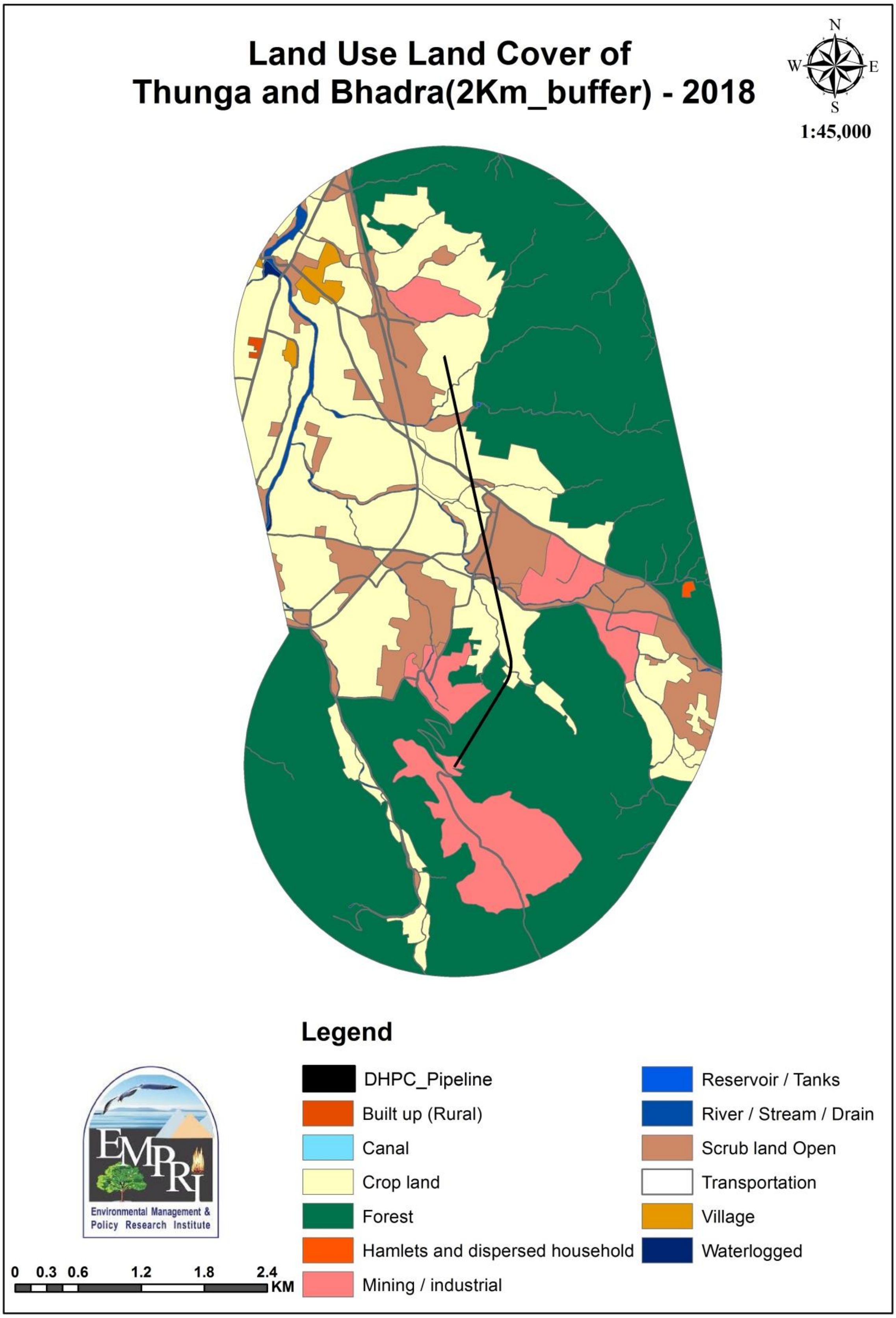


Figure 8.17 Land Use/ Land Cover – 2018 for 2 Km buffer

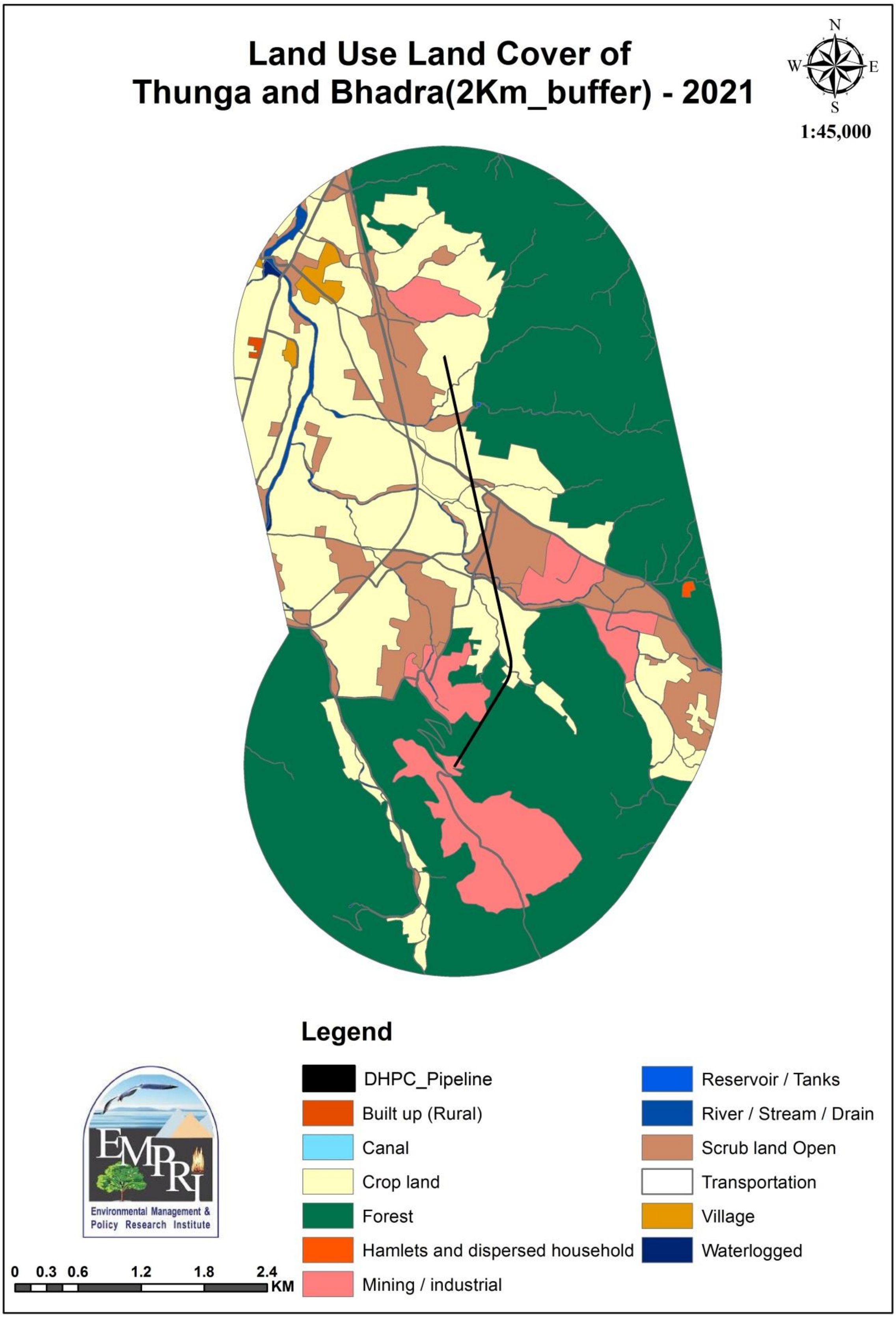


Figure 8.18 Land Use/ Land Cover – 2021 for 2 Km buffer

8.2.2 Accuracy Assessment

One of the most important step at classification process is Accuracy Assessment. The aim of Accuracy Assessment is to quantitatively assess how effectively the interpretations of the images are classified. To analyse the accuracy assessment 1km*1km grids are laid for entire study area. A total of 628 Points (locations) were created in the classified image of the study area by fixing the point at the centre of each grid. The points are verified on the high resolution google earth images and the LISS IV satellite imageries. Details of Accuracy Assessment are given in Table 8.8.

Table 8.8 Accuracy Assessment table

Sl No	LU/LC classes	Sample points	Correct sampled
1	Agricultural Plantation	2	2
2	Barren rocky	5	5
3	Built-up(Rural)	6	6
4	Built-up(Urban)	1	1
5	Crop Land	202	196
6	Forest	266	264
7	Industry	24	24
8	Mining	25	25
9	River/stream/Drain	27	27
10	Scrubland open	58	56
11	Transportation	3	3
12	Village	2	2
13	Waterlogged	6	6
	Total	**627**	**617**

- The overall accuracy percentage is calculated by the following formula
- Classification accuracy percentage = (No. of correct sampled points/total number of sample points) *100
- Classification accuracy percentage = (617/627)*100
- Classification accuracy percentage=98.4%
- The overall accuracy percentage obtained is 98.4%

8.2.3 Overlay analysis

To estimate the land transformation from one class to another class overlay analysis is carried out. In the current study two sets of vector feature classes such as 2012 and 2021 LU/LC are considered to analyse spatial relationship and change detection. Using the attribute information, the change detection is analysed to trace the transformation in LU/LC. The statistical representation of Individual class, indicates the conversion of particular LU/LC to and from various other classes is detailed below.

1. **Forest:** The forest land in the study area is converted to other LU/LC classes such as Agriculture plantation, Built up (Rural), Crop land, Hamlets and dispersed household, Mining / industrial and Reservoir / Tanks from 2012 to 2021. The detailed tabulation is shown in the Table 8.9, 8.10 and 8.11 respectively for Devadari, Tunga & Bhadra and Rama DHPC for10 km buffer.

Table 8.9 Distribution of LU/LC Classes in Forest in 10 km buffer of Devadari

Year	LULC class	Area in Ha
2012	Forest	19844.83
Unchanged area		
2021	Forest	19375.15
Forest to other classes		
2021	Agriculture plantation	0.12
2021	Built up (Rural)	0.76
2021	Crop land	112.26
2021	Hamlets and dispersed household	0.45
2021	Mining / industrial	355.52
2021	Reservoir / Tanks	0.00
2021	Scrub land Open	0.57
Total		469.68

Table 8.10 Distribution of LU/LC Classes in Forest in 10 km buffer of Rama

Year	LULC class	Area in Ha
2012	Forest	26945.65
Unchanged area		
2021	Forest	26654.94
Forest to other classes		
2021	Built up (Rural)	0.76
2021	Crop land	193.82
2021	Hamlets and dispersed household	0.28
2021	Lakes / Ponds	0.03
2021	Mining / industrial	93.08
2021	Reservoir / Tanks	0.72
2021	Scrub land Open	1.71
2021	Village	0.31
Total		290.71

Table 8.11 Distribution of LU/LC Classes in Forest in 10 km buffer of Tunga and Bhadra

Year	LULC class	Area in Ha
2012	Forest	16983.69
Unchanged area		
2021	Forest	16736.28
Forest to other classes		
2021	Agriculture plantation	0.12
2021	Built up (Rural)	0.05
2021	Crop land	79.93
2021	Hamlets and dispersed household	8.85
2021	Lakes / Ponds	0.01
2021	Mining / industrial	152.84
2021	Reservoir / Tanks	0.72
2021	River / Stream / Drain	0.00
2021	Scrub land open	4.88
	Total	**247.41**

2. **Water bodies**: There are four sub classes namely

- Lakes / Ponds
- Canals
- River / Stream / Drain
- Reservoir / Tanks

There are no changes from Lakes /Canals/ Ponds and River / Stream / Drain to various other LU/LC classes. Changes are observed from Reservoir / Tanks to crop land in study area. It is observed that when the water level is decreased the piece of land is converted into crop land. The details are tabulated in the Table 8.12, 8.13 and 8.14.

Table 8.12 Distribution of LU/LC Classes from Reservoir/Tanks in 10 km buffer of Devadari

Year	LULC class	Area in Ha
2012	Reservoir / Tanks	323.85
Changed area		
2021	Reservoir / Tanks	323.70
Reservoir / Tanks to other classes		
2021	Crop land	0.14
	Total	**0.14**

Table 8.13 Distribution of LU/LC Classes from Reservoir / Tanks in 10 km buffer of Rama

Year	LULC class	Area in Ha
2012	Reservoir / Tanks	756.12
Changed area		
2021	Reservoir / Tanks	746.73
Reservoir / Tanks to other classes		
2021	Crop land	8.72
2021	Lakes / Ponds	0.67
	Total	**0.67**

Table 8.14 Distribution of LU/LC Classes from Reservoir / Tanks in 10 km buffer of Tunga and Bhadra

Year	LULC class	Area in Ha
2012	Reservoir / Tanks	652.22
Changed area		
2021	Reservoir / Tanks	782.26
Reservoir / Tanks to other classes		
2021	Crop land	107.74
2021	Gullied / ravenous	18.72
2021	Scrub land Open	3.72
	Total	**130.17**

3. Waste land: There are six major sub classes namely

- Barren rocky
- Gullied / Ravenous
- Salt affected
- Sandy areas
- Scrub land Dense
- Scrub land Open
- Waterlogged

Changes from waste land to various other LU/LC classes are identified only from Scrub land Open, Scrub land Dense and waterlogged. And no changes have been observed in other classes of waste lands.

Scrub land Open: The changes occurred in Scrub land Open are tabulated in table below scrub land open has been converted to other LU/LC classes mainly to crop land area in 10 km buffer. The details are tabulated in Table 8.15, 8.16 and 8.17.

Table 8.15 Distribution of LU/LC Classes in Scrub land Open in 10 km buffer of Devadari

Year	LULC class	Area in Ha
2012	Scrub land Open	957.13
Unchanged area		
2021	Scrub land Open	856.67
Scrub land Open to other classes		
2021	Agriculture plantation	0.05
2021	Crop land	75.19
2021	Hamlets and dispersed household	3.17
2021	Mining / industrial	14.67
2021	Peri urban	7.38
	Total	**100.46**

Table 8.16 Distribution of LU/LC Classes in Scrub land Open in 10 km buffer of Rama

Year	LULC class	Area in Ha
2012	Scrub land Open	1079.58
Unchanged area		
2021	Scrub land Open	959.97
Scrub land Open to other classes		
2021	Built up (Rural)	3.93
2021	Crop land	102.60
2021	Forest	0.02
2021	Hamlets and dispersed household	3.22
2021	Lakes / Ponds	1.90
2021	Peri urban	7.38
2021	Village	0.57
	Total	**119.61**

Table 8.17 Distribution of LU/LC Classes in Scrub land Open in 10 km buffer of Tunga and Bhadra

Year	LULC class	Area in Ha
2012	Scrub land Open	3313.67
Unchanged area		
2021	Scrub land Open	2942.65
Scrub land Open to other classes		
2021	Agriculture plantation	0.05
2021	Built up (Rural)	1.17
2021	Crop land	309.92
2021	Hamlets and dispersed household	11.74
2021	Lakes / Ponds	0.66
2021	Mining / industrial	28.73
2021	Peri urban	7.38
2021	Reservoir / Tanks	3.72

2021	Salt affected	5.71
2021	Village	1.95
	Total	**371.02**

Scrub land Dense: The changes occurred in Scrub land dense are tabulated in table below scrub land open has been converted to other LU/LC classes mainly to crop land area in 10 km buffer. The details are tabulated in Table 8.18, 8.19 and 8.20.

Table 8.18 Distribution of LU/LC Classes in Scrub land dense in 10 km buffer of Devadari

Year	LULC class	Area in Ha
2012	Scrub land Dense	47.75
Changed area		
2021	Scrub land Dense	46.05
Scrub land Dense to other classes		
2021	Village	1.69
Total		1.69

Table 8.19 Distribution of LU/LC Classes in Scrub land dense in 10 km buffer of Rama

Year	LULC class	Area in Ha
2012	Scrub land Dense	40.67
Changed area		
2021	Scrub land Dense	38.97
Scrub land Dense to other classes		
2021	Village	1.69
Total		1.69

Table 8.20 Distribution of LU/LC Classes in Scrub land dense in 10 km buffer of Tunga and Bhadra

Year	LULC class	Area in Ha
2012	Scrub land Dense	50.70
Changed area		
2021	Scrub land Dense	49.01
Scrub land Dense to other classes		
2021	Village	1.69
Total		1.69

Waterlogged: The changes occurred in Waterlogged areas are tabulated in table below Waterlogged area is converted to crop land and ponds in Rama and Tunga & Bhadra study area. The details are tabulated in Table 8.21and 8.22.

Table 8.21 Distribution of LU/LC Classes in Waterlogged area in 10 km buffer of Rama

Year	LULC class	Area in Ha
2012	Waterlogged	3.77
Changed area		
2021	Waterlogged	3.340
Waterlogged to other classes		
2021	Crop land	0.10
2021	Lakes / Ponds	0.33
Total		0.43

Table 8.22 Distribution of LU/LC Classes in Waterlogged area in 10 km buffer of Tunga and Bhadra

Year	LULC class	Area in Ha
2012	Waterlogged	3.77
Changed area		
2021	Waterlogged	3.340
Waterlogged to other classes		
2021	Crop land	0.10
2021	Lakes / Ponds	0.33
Total		**0.43**

8.2.3.1 Findings

- The assessment of LU/LC status in the study area and the change detection studies have been carried out with maps of 1:20000 scale as per SIS-DP (Space Based Information Support for Decentralised Planning) guidelines prepared by Indian Space Research Organization (ISRO) published on 2011, 6 major classes of LU/LC exist in study area. This analysis discusses various characteristics and vulnerable classes of the study area and the details for each one of these are given above.
- 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. An extent of 469 Ha, 282 Ha and 245 Ha of forest lands are decreased in 10km buffer of Devadari, Rama and Tunga and Bhadra DHPC respectively.
- An extent of 469 Ha, 282 Ha and 245 Ha of forest lands in 10km buffer of Devadari, Rama and Tunga and Bhadra DHPC respectively are converted to other LU/LC classes mainly to mining/ industrial area and built-up area. Due to these changes we have lost natural resources and biodiversity in the ecosystem.

- 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 425.35 Ha in Devadari, 136.23 Ha in Rama and 181.94 Ha in Tunga and Bhadra DHPC. This change in LU/LC includes major portion of forest land, getting converted into mining/industry.

9 Summary and conclusion

i. Study area is restricted to three Downhill Pipe Conveyors

   a. M/s. Devadari Iron ore Mines – Construction of DHPC completed
   b. M/s. Tunga and Bhadra Iron ore Mines – Under construction
   c. M/s. Rama Iron ore Mines – Construction not yet started

ii. Four waterbodies were inventoried in Rama DHPC and one water body in Devadari DHPC whereas no active water body was found in Tunga and Bhadra DHPC study area.

iii. The surface water quality of Hulikunte kere has improved in season III (Category – B) compared to season II (Category – C).

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

v. In three DHPCs, 14 locations were identified for study of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 concentration during season II and III. The observation is that the PM_{10} concentrations in all the 14 locations were above the National Ambient Air Quality Standards. Out of 14 locations $PM_{2.5}$ concentrations were higher than the National Ambient Air Quality Standards in 10 locations. In 4 locations i.e., Tunga & Bhadra road intersect point, Tunga & Bhadra 1st pillar point, Rama hopper point and Ramgad village the concentrations were within the permissible limits. NO_2 concentration in all the locations was within the limits. SO_2 concentration was higher than the prescribed standards in 11 locations except Bhujanganagar School**,** Bannihatti transfer point and Road intersect point.

vi. The noise levels observed in the study area were well within the CPCB standards except at 1st pillar point during day time (50.39 dB(A)) and during night time (44.02 dB(A)); at Bhadra hopper point during night time (41.20 dB(A)) in season II whereas at Devadari transfer point (42.05 dB(A)), Bannihatti school (42.04 dB(A)) and at Sushilnagar school (47.24 dB(A)) during night time in season III respectively.

vii. Soil results revealed that the soil is alkaline with higher Electrical Conductivity was 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 minimum temperature of 12.3°C and maximum temperature of 37.4°C as per recorded primary data in February 2022 and March 2022 in Devadari DHPC. Maximum rainfall of 14 mm and minimum humidity of 55.5% was observed in November 2021 and March 2022 respectively in Rama DHPC. Predominant wind direction in the study area was found to be North and North-North-East respectively.

ix. Socio-economic survey carried out in fourteen villages of Devadari DHPC revealed that the majority households were not affected financially and had no impact on their livelihood. Tunga & Bhadra and Rama DHPCs socio-economic survey is under progress.

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 469 Ha, 245 Ha and 282 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.

10 References

Anchan, S. S., Shetty, A., Bhat, H G., Chadaga, M. (2018). Land use and land cover change detection through spatial approach: A case study of Mangaluru Taluk, Karnataka. *Journal of Geomatics*. 12(2): 167-173.

Applied development economics, Inc report on final socioeconomic analysis of the 2017 bay area (Clean air plan 2017).

Asselman, N. E. M. and Middelkoop, H. (1995). Floodplain sedimentation: quantities, patterns and processes. *Earth Surface Processes & Landforms*. 20 (6):481–499.

Azeez, A. and Mukhitdinov, S. (2020). Land use land cover change detection in the mining areas of Yalevsky coal mine Russia. *E3S Web of Conferences*. 192: 1-9.

Babu, S., Muthyam, S., and Rao, V. (2013). Inventory, mapping and monitoring of surface water bodies. *NNRMS Bulletin*. 24-33.

Bala, M., and Verma, D. (2020). Investigation and examination of noise pollution-definition, sources, effects, monitoring and control. *International Journal of Research in Social Sciences*. 10(7): 182-207.

Balasubramanian, A. (2015). Classification of lakes. 10.13140/rg.2.2.19008.33282

Blickley, J. L., Blackwood, D., and Patricelli, G. L. (2012). Experimental evidence for the effects of chronic anthropogenic noise on abundance of greater sage-grouse at lakes. *Conservation Biology*. 26(3): 461-471.

Bortnowski, P., Anna, N.S., Król, R., and Maksymilian Ozdoba, M. (2021). Analysis and distribution of conveyor belt noise sources under laboratory conditions. *Sustainability*. 13:1-14.

Brown, R.M., McClelland, N.I., Deininger, R.A., Connor M.F. (1972). A water quality index-crashing the psychological barrier. *Indicators of Environmental Quality*. 1(1): 173-178.

Buchanan, C. (1985). Japan pipe belt conveyor system. *Proceedings of International Materials Handling Conference*. 1-9.

Census of 2011, Population of India, New Delhi. (https:www.censusindia.gov.in).

Central Pollution Control Board, (2009). Guidelines for the measurement of ambient air pollutants. Volume-I, New Delhi.

Central Pollution Control Board, (2019). National ambient air quality status and trends 2019. New Delhi.

Chaulya, S.K., Trivedi, R., Kumar, A., Tiwary, R.K., Singh, R.S., Pandey, P.K., and Kumar, R. (2019). Air quality modelling for prediction of dust concentrations in Iron ore mines of Saranda region, Jharkhand, India. *Atmospheric Pollution Research*. 10: 675-688.

Clark, C., Crombie, R., Head, J., Kamp, I., Kempen, E., Stansfeld, S. A. (2012). Does traffic-related air pollution explain associations of aircraft and road traffic noise exposure on children's health and cognition? A secondary analysis of the United Kingdom sample from the Ranch project. *American Journal of Epidemiology*. 176(4): 327-337

Contemplated table for (IRS 1D –PAN + LISS-III /LISS IV Mx) from SIS-DP manual, Preparation of Geo Spatial Layers using High Resolution (Cartosat – 1 Pan + LISS- IV Mx) Orthorectified Satellite Imagery, NRSC(ISRO), DoS, GoI. Dec 2020.

Dash, A.K., Pradhan, A., and Patra, H.S. (2016). Soil physico-chemical characteristics near the mining areas of Keonjhar district, Odisha, India. International *Journal of Current Research*. 8(5): 30306-30309.

Dubey, K. (2017). Socio economic impact study of mining and mining policies on the livelihood of local population in the Vindhyan region of Uttar Pradesh. *Report submitted to NITI Aayog*, New Delhi (Government of India).

EMPRI. (2021). Evaluation of the impact of increased timings of the operation of the main pipe conveyor from Nandihalli yard to JSW plant on wildlife. *Report submitted to MoEF&C.*

Fedorko, G. (2010). Variable pipe conveyor. Annals of DAAAM and proceedings of the International DAAAM symposium. 21(1):1-2.

Ganguly, R., Batterman, S., Isakov, V., Breen, M., and Caldwell, W.B. (2015). Effect of geocoding errors on traffic-related air pollutant exposure and concentration estimates. *Journal of Exposure Science and Environmental Epidemiology*. 25(5): 490-498.

Ganguly, R., Sharma, D., and Kumar, P. (2021). Short-term impacts of air pollutants in three megacities of India during COVID-19 lockdown. *Environment, Development and Sustainability*. 23: 18204 -18231.

Ganiyu, S.A., and Ogunsote, O.O. (2010). A study of sources and control of environmental noise pollution on a typical street in Akure, Nigeria. A paper presented in an International Conference organised by School of Environmental Technology, Federal University of Technology, Akure.

Gaonkar, G.V., and Gudagur, J.T., Tejaswi, L. (2016). Impact of mining on surface water quality in the Western part of Sandur Schist Belt, Karnataka, India – a preliminary investigation. *International Journal of Advanced Research*. 4: 1475-1482.

Garai, D., and Narayana, A.C. (2018). Land use/land cover changes in the mining area of Godavari coal fields of Southern India. *The Egyptian Journal of Remote Sensing and Space Sciences*. 21:375–381.

Gowda, A.J., Sundar, K.M.S., Nagarajappa, D.P., Kusasur, A., and Lokeshappa, B. (2015). Concentration and distribution of particulate matter in Subbarayanahalli Iron ore mine, Sandur, Karnataka, India –A case study. *International Journal of Research in Engineering and Technology*. 4(5): 219-223

Guttikunda, S.K., Goel, R., Pant, P. (2014). Nature of air pollution, emission sources and management in the Indian cities. *Atmospheric Environment*. 95: 501-510.

Hangaragi, S.S. (2016). Assessment of land use and land cover change of sustainable development of Sandur taluk of Ballari district, Karnataka using remote sensing technology. *Indian Journal of Regional Science*. 48(1): 145-154.

Islam, M.M., and Mustaquim, M. (2014). Socio economic status of rural population: An income level asnalysis. *Asian Academic Research Journal of Multidisciplinary*. 1 (24): 98-106.

Jat, M. K., Garg, P. K. and Khare, D. (2008). Monitoring and modelling of urban sprawl using remote sensing and GIS techniques. *International Journal of Applied Earth Observation and Geoinformation*. 10 (1): 26–43.

Kawalec, W., Król, R., and Suchorab, N. (2020). Regenerative belt conveyor versus haul truck-based transport: Polish open-pit mines facing sustainable development challenges. *Sustainability*. 12: 1-15.

Kesimal, A. (1997). Different types of belt conveyors and their applications in surface mines. *Mineral Resources Engineering*. 6(4): 195-219.

Krol, R., Kawalec, W., Gladysiewicz. (2017). An effective belt conveyor for underground ore transportation systems. *Earth and Environmental Science*. 95: 1-10.

Kumar. V. N., and Basavaraja. T. (2020). Health status of mining labourers in Ballari District. *International Journal of Economics and Financial Issues*. 1(1-2):1-10.

Kumar, R.K.S., Chinnaiah, and Kumar, B.V.S., (2012). Detection studies of land use/land cover changes in Sandur Taluk, Ballari District, Karnataka, India using remote sensing and GIS techniques. *International Journal of Earth Sciences and Engineering*. 5(1): 133-137.

Kumar, R.K.S., Kumar, B.V.S., and Manjunatha, S. (2012). Estimation of surface and groundwater pollution due to mining activity by Geo-chemical methods and re-vegetation site selection using Remote Sensing and GIS techniques in the parts of Sandur schist belt, South India. *Nature Environment and Pollution Technology*. 11(3): 403-408.

Kumar, B.V.S., Kumar, R.K.S., and Narasimha, K.N.P. (2016). Water quality assessment in and around Sandur Taluk, Ballari District, South India. International *Journal of Advanced Earth Science and Engineering*. 5(1): 325-332.

Ladanyi, G. (2016). Study on the noise emission of belt conveyor idler rolls. *Annals of the University of Petrosani, Mechanical Engineering*. 18: 83-92.

Liu, Z., Shen, L., Yan, C., Du, J., Li, Y., and Zhao, H. (2020). Analysis of the influence of precipitation and wind on PM2.5 and PM10 in the atmosphere. *Advances in Meteorology*. 1-13.

Madhukar, R., and Srikantaswamy, S. (2013). Impact of industrial effluents on the water quality of Vrishabavathi river and Byramangala lake in Bidadi industrial area, Karnataka, India. *International Journal of Geology, Earth and Environmental Sciences.* (3):132-140.

Maksarov, V., Zlotnikov, E., and Olt, J. (2017). Determining the load on support rollers the pipe conveyor belt. *In annals of DAAAM and proceedings of the International DAAAM symposium*. 209-215.

Martins R.S., Ceniz, J.P., Luersen, M.A., and Cousseau, T. (2020). Design of a conveyor belt idler roller using a hybrid topology/parametric optimization approach. *CILAMCE, Proceedings of the XLI Ibero-Latin-American Congress on Computational Methods in Engineering*, Brazil.

Mi, J., Yang, Y., Zhang, S., An, S., Hou, H., Hua, Y., and Chen, F. (2019). Tracking the Land Use/Land Cover change in an area with underground mining and reforestation via continuous land sat classification. *Remote Sensing*. 11: 1719.

Maktav, D., Erbek, F. S., and Jürgens, C. (2005). Remote sensing of urban areas. *International Journal of Remote Sensing*. 26 (4):655–659.

Molnar, V., Fedorko, G., Stehlikova, B., and Paulikova, A. (2015). Influence of tension force asymmetry on distribution of contact forces among the conveyor belt and idler rolls in pipe conveyor during transport of particulate solids. *Measurement*. 63: 120-127.

Nasir, H., Goyal, K., and Prabhakar, D. (2016). Review of air quality monitoring: Case study of India. *Indian Journal of Science and Technology*. 9(44): 1-8.

Neba, N. E., and Ngeh, B. P. (2009). Socio-economic impact of the chad - Cameroon oil pipeline in ocean division, Cameroon. *Journal of Human Ecology*. 27 (3): 175-183.

Pierce, S. A., Sharp, J. M., Eaton, D. J. (2016). Decision support systems and processes for groundwater. *Integrated Groundwater Management*. 639-665.

Priyanka and Megha (2018). Social structure of Bilawal village in Badhra block of Haryana: A geographical analysis. *International Journal of Engineering Development and Research*. 6(1): 763-770.

Ramamoorthy, P., and Rammohan, V. (2015). Assessment of groundwater potential zone using remote sensing and GIS in Varahanadhi watershed, Tamil Nadu, India. *International Journal for Research in Applied Science and Engineering Technology*. 3 (5): 695-702.

Ravikumar, P., Mehmood, M., and Somashekar, R.K. (2013). Water quality index to determine the surface water quality of Sankey tank and Mallathahalli lake, Bangalore Urban District, Karnataka, India. *Applied Water Science*. 3: 247–261.

Robles, B., and Luna, A. (2002). Land use mapping and change detection in the coastal zone of northwest Mexico using remote sensing techniques. *Journal of Coastal Research*. 18(3), 514–522.

Russo, D., Jones, G., and Arlettaz, R. (2001). Echolocation and passive listening by foraging mouse-eared bats Myotis Myotis and M. Blythii. *Journal of Experimental Biology*. 210(1): 166-176.

Sadowski, J. (2005). Minimization of noise in foundries on the example of the Iron founry in Bydgoszcz. *Journal of Polish Cimac*. 1-10.

Sadowski, J., and Fąs, T. (2014). Noise minimization of belt conveyor used for lignite coal transportation. *Chemical Engineering and Equipment*. 2: 113–115.

Seth, R., Mohan, M., Singh, P., Singh, R., Dobhal, R., Singh, K. P., and Gupta, S. (2014). Water quality evaluation of Himalayan rivers of Kumaun region, Uttarakhand, India. *Applied Water Science*. 6, 137-147.

Shukla, S. P., Agrawal, V., Singh, N. B., Shukla, R., Bhargava, D., and Behera, S. (2011). Water quality index of surface water quality in an industrial area in Kanpur city. *Journal of Institution of Engineers*. 92:18-22.

Silarska, M.P., Pytel, K., Gumula, S., and Hudy, W. (2019). Evaluation of the impact of meteorological conditions on the amount of air pollution in Krakow. Energy and *Fuels.* 108: 1-8.

Singh, G., and Perwez, A. (2015). Depreciation in ambient air quality in Iron ore mining region of Goa. *Current World Environment*. 10(1):149-160.

Shrivastava, A., Krishnan, A., and Mishra, R.K. (2018). Status of ambient air quality in Khondbond Iron ore mines, Orissa (India). *International Journal of Advance Research in Science and Engineering*. 7(6): 244-251.

Suresh, T., Kottureshwara, N.M. and Revanasiddappa, M. (2009). Assessment of groundwater quality in and around Ballari city of Karnataka, India. *Nature, Environment and Pollution Technology*. 8 (4): 683-692.

Thotappaiah, M., Suresh, T., Manjappa, S., and Suresh, B. (2019). Studies on cyclic variation in ground water quality of Sandur taluk, Ballari district, India: A Cation, anion balance and statistical approach. *Global Scientific Journals*. 7(7): 1415-1427.

Umar, H. A., Khanan, A. M. F., Ogbonnaya, C., Shiru, M. S., Ahmad, A., and Baba, A. I. (2021). Environmental and socio economic impacts of pipeline transport interdiction in Niger delta, Nigeria. *Heliyon*. 7 (5): 1-10.

Working plan of Ballari Forest Division Karnataka 2013-14 to 2022-23 by Vijay Lal Meena, IFS. Chief Conservator of Forests, working plan, Ballari, GoK 2013-14 to 2022-23.

11 List of Tables

12 List of Figures

13 List of Annexures

ANNEXURE – I

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 27

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

ಪರಿಸರ ನಿರ್ವಹಣೆ ಮತ್ತು ನೀತಿ ಸಂಶೋಧನಾ ಸಂಸ್ಥೆ
ದಾಖಲಿಸಿದೆ
ಸ್ವೀಕೃತಿ ಸಂಖ್ಯೆ 1057
ದಿನಾಂಕ 06.08.2020

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-

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;*

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.*

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.

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.

ANNEXURE – II

सत्यमेव जयते

INDIA NON JUDICIAL

Government of Karnataka

e-Stamp

Certificate No.	:	IN-KA96109378360684T
Certificate Issued Date	:	06-Apr-2021 11:00 AM
Account Reference	:	NONACC (BK)/ katmbbk02/ M G ROAD1/ KA-BA
Unique Doc. Reference	:	SUBIN-KAKATMBBK02638966248241 15T
Purchased by	:	JSW STEEL LIMITED
Description of Document	:	Article 12 Bond
Description	:	MEMORANDUM OF UNDERSTANDING
Consideration Price (Rs.)	:	0 (Zero)
First Party	:	JSW STEEL LIMITED
Second Party	:	E M P R I
Stamp Duty Paid By	:	JSW STEEL LIMITED
Stamp Duty Amount(Rs.)	:	200 (Two Hundred only)

Please write or type below this line

MOEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (MoU) is hereby executed on the 06th day of April, 2021 at Bengaluru between M/s. JSW Steel Limited, Ballari, Karnataka hereinafter referred to as JSW (Herein after called as the First Party).

And Environmental Management and Policy Research Institute (EMPRI), which is functioning under Department of Forest, Ecology and Environment, Government of Karnataka having its registered office at "Hasiru Bavana" Doresanipalya Forest Camps, Vinayakanagar Circle, J. P. Nagar 5th phase, Bengaluru-560078, Karnataka, represented by Sri. B. Basavaraju, Head - Training, EMPRI, (Herein after called as the Second party).

B. Basavaraju
Head Training
ENVIRONMENTAL MANAGEMENT & POLICY RESEARCH INSTITUTE

WHEREAS,

JSW has proposed transportation of Iron Ore from mines to the Plant using Down Hill Pipe Conveyor (DHPCs) System, which is environment friendly. Since forest area was involved in the proposed DHPC system, as a part of Stage I Forest Clearances of Three DHPCs, a condition was stipulated was as under by MoEF&CC:

Condition No. 10.: The user agency shall conduct a study, at its cost, involving a reputed Institute on impact of downhill pipe conveyor on 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.

Accordingly, Government of Karnataka, requested the Director General EMPRI, Bengaluru to prepare a draft Terms of Reference for the studies stipulated in Stage I approval as per the condition stipulated by the Government of India.

In Response, DG EMPRI submitted Terms of Reference for ambient environment component of the study, which was approved by the PCCF & HOFF, Govt. of Karnataka(vide letter no. Old file no: A5(1).MNG.CR-9/2017-18; E-office File no. KFD/HOFF/A5-1(MNG)/46/2018-FC dated 27.07.2020. It was also mentioned in the approval letter that the cost of the study shall be completely borne by the JSW (user agency in the FC proposals) and paid directly to EMPRI in accordance with the mutual agreement, which is provided below:

Accordingly, the cost proposed by EMPRI (INR. 4,49,73,421/-) for the Five years, and 70% of the amount of the First Year study was released to EMPRI by the JSW on 5th January, 2021.

As per the letter of PCCF & HOFF, Govt. of Karnataka, both the parties have entered into the following agreements:

THIS MEMORANDUM OF UNDERSTANDING WITNESSETH AS UNDER:

1. 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 forested areas to undertake the study.
2. The Study proponent shall submit the 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 the Office of PCCF & HOFF, Govt. of Karnataka.
3. Scope of the study: The study shall be as per the Terms of References as approved by the PCCF & HoFF, Karnataka (vide letter no. Old file no: A5(1).MNG.CR-9/2017-18; E-office File no. KFD/HOFF/A5-1(MNG)/46/2018-FC dated 27.07.2020 (copy enclosed).
4. Duration of Project: The duration of project is 5 years and the contract shall come into force on the date from commencement of the project i.e., 5th January 2021 and shall be completed within the period of 5 years.

JSW ... Bellary Dist. Karnataka ... 583 275

B. Basavaraju
Head Training
ENVIRONMENTAL MANAGEMENT & POLICY RESEARCH INSTITUTE
Bangalore - 560 078.

5. The amount allocated for the study per year should be released in two instalments. First instalment in the First Week of April and Second instalment in the First week of September in each year.
6. To carry out subsequent year's studies, the funds will be released by JSW, on the receipt of Final Report, annually, in two instalments.
7. JSW will provide correct information and access to field for collecting the baseline information of the project area.
8. EMPRI will submit the fund utilisation certificate every year.
9. Other Conditions:
   - This MoU shall be operative until the completion of study finalization of the final report by EMPRI, Bengaluru.
10. There shall be periodic review meetings of the stakeholders on the progress of the assignment work under MoU.
11. In case of any disagreement between the parties, the appeal would lie with the PCCF & HoFF, whose decision will be final.

Good Faith:

The parties undertake to act in Good Faith with respect to each other rights under this contract and to adopt all reasonable measures to ensure the realisation of the objective of this MoU.

IN WITNESS WHERE OF, the undersigned duly authorized there to have signed this Memorandum of understanding.

For & On behalf of JSW, Ballari

Name: Dr. Subhash Mali
Designation: Assistant General Manager
Environment, Mining Department,
JSW steel Limited, Vijayanagar works Ballari

Date: 06.04.2021
Place: Bangalore

JSW Steel Ltd., Vidyanagar-583 275, Bellary Dist, Karnataka

For & On behalf of EMPRI, Bengaluru

Name: Sri B. Basavaraj
Designation: Head, Training
EMPRI Bengaluru

B. Basavaraju
Head Training
ENVIRONMENTAL MANAGEMENT & POLICY RESEARCH INSTITUTE
Bangalore - 560 078.

Date: 06-04-2021
Place: Bangalore

Bangalore - 560

ANNEXURE – III

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
□ $\leq$ 25% □ $\leq$50% □ $\leq$75% □ $\leq$ 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:

ಕ್ರಮ ಸಂಖ್ಯೆ : ________

ಅರಣ್ಯ, ಪರಿಸರ ಮತ್ತು ಹವಮಾನ ಬದಲಾವಣೆ ಸಚಿವಾಲಯ ನಿಗದಿಪಡಿಸಿದಂತೆ ಸುಧಾರಿತ ಅದಿರು ಸಾಗಾಣಿಕಾ ನಳಿಕೆಯ (JSW Downhill Pipe Conveyor) ಪರಿಸರ ಪರಿಣಾಮಗಳ ಮೌಲ್ಯಮಾಪನ

ಪರಿಸರ ನಿರ್ವಹಣೆ ಮತ್ತು ನೀತಿ ಸಂಶೋಧನಾ ಸಂಸ್ಥೆ

ಅರಣ್ಯ, ಪರಿಸರ ಮತ್ತು ಜೀವಿಶಾಸ್ತ್ರ ಇಲಾಖೆ ಕರ್ನಾಟಕ ಸರ್ಕಾರ

ಸಾಮಾಜಿಕ-ಆರ್ಥಿಕ ಸಮೀಕ್ಷೆಯ ಪ್ರಶ್ನೆ

ಯೋಜನಾ ಪ್ರದೇಶ : ದೇವದಾರಿ ಡಿಎಚ್ಪಿಸಿ ☐ ತುಂಗ & ಭದ್ರಾ ಡಿಎಚ್ಪಿಸಿ ☐ ರಾಮ ಡಿಎಚ್ಪಿಸಿ ☐

I. ಸಾಮಾನ್ಯ ಮಾಹಿತಿ

ಕುಟುಂಬದ ಮುಖ್ಯಸ್ಥರ ಹೆಸರು : ________________________________

ಗ್ರಾಮದ ಹೆಸರು:________________________________

ಅಂಚೆ ವಿಳಾಸ:________________________________

ಹೋಬಳಿ/ತಾಲ್ಲೂಕು:________________________________

ಜಿಲ್ಲೆ:________________________________

1. ಲಿಂಗ : ಸ್ತ್ರೀ ☐ ಪುರುಷ ☐

2. ವಯಸ್ಸು: ___________

3. ಧರ್ಮ: ಹಿಂದೂ ☐ ಮುಸ್ಲಿಂ ☐ ಕ್ರಿಶ್ಚಿಯನ್ ☐ ಇತರೆ ☐

4. ಜಾತಿ: GM ☐ OBC ☐ SC/ST ☐ ಇತರೆ ☐

5. ಮಾತೃಭಾಷೆ: ಕನ್ನಡ ☐ ಹಿಂದಿ ☐ ತೆಲುಗು ☐ ಇತರೆ ☐

6. ಕುಟುಂಬ ಸದಸ್ಯರ ಸಂಖ್ಯೆ: ______

7. ಕುಟುಂಬದ ಮುಖ್ಯಸ್ಥನ ಶಿಕ್ಷಣದ ಮಟ್ಟ:

ಪ್ರಾಥಮಿಕ ☐ ಪ್ರೌಢಶಾಲೆ ☐ ಪದವಿ ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

8. ಕುಟುಂಬದ ಮುಖ್ಯಸ್ಥನ ಉದ್ಯೋಗ: ರೈತ ☐ ಸರ್ಕಾರಿ ಉದ್ಯೋಗಿ ☐ ಖಾಸಗಿ ☐ ಇತರೆ ☐

II. ಆರ್ಥಿಕ ಸ್ಥಿತಿ

9. ಕುಟುಂಬದ ಮುಖ್ಯಸ್ಥನ ವಾರ್ಷಿಕ ಆದಾಯ:

< Rs 1,00,000 /- ☐ > Rs 1,00,000 /- ☐ > Rs 2,00,000/- ☐ > Rs 4,00,000 /- ☐

10. ಆಸ್ತಿಯ ವಿಧ : ಸ್ವಂತ ಭೂಮಿ ☐ (ವಿಸ್ತಾರ (ಎಕರೆಗಳಲ್ಲಿ): -------------)

ಕಟ್ಟಡ ☐ ವಾಹನ ☐ ಇತರೆ ☐

11. ಆಸ್ತಿ ಮಾಲೀಕತ್ವ: ವೈಯಕ್ತಿಕ ☐ ಜಂಟಿ ☐ ಬಾಡಿಗೆ ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

12. ಮನೆ: ಕಾಂಕ್ರೀಟ್ ಮನೆ ☐ ಹೆಂಚಿನ ಮನೆ ☐ ಶೀಟ್ ಮನೆ ☐ ಇತರೆ ☐

13. ವಿದ್ಯುತ್ ಸಂಪರ್ಕ: ಇದೆ ☐ ಇಲ್ಲ ☐

14. ಕುಡಿಯುವ ನೀರಿನ ಮೂಲ: ಬೋರ್ ವೆಲ್ ☐ ಮೇಲ್ಮೈನೀರು ☐ ತೆರೆದಬಾವಿ ☐ ಇತರೆ ☐

15. ಕೃಷಿಗೆ ನೀರಿನ ಮೂಲ: ಮಳೆ ನೀರು ☐ ಅಂತರ್ಜಲ ☐ ಮೇಲ್ಮೈ ನೀರು ☐ ಇತರೆ ☐

16. ಜಾನುವಾರಗಳ ಮಾಹಿತಿ: ಹಸು ☐ ಕುರಿ ☐ ಕೋಳಿ ☐ ಇತರೆ ☐

17. ಸ್ವಂತ ವಾಹನಗಳು: ದ್ವಿಚಕ್ರ ☐ ನಾಲ್ಕುಚಕ್ರ ☐ ಇತರೆ ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

18. ಅಡುಗೆ ಮಾಡಲು ಬಳಸುವ ಇಂಧನ ಪ್ರಕಾರ:

LPG ಸಿಲಿಂಡರ್ ☐ ಕಟ್ಟಿಗೆ ☐ ಜೈವಿಕ ಅನಿಲ ☐ ಇತರೆ ☐

19. ಕೃಷಿ ಉಪಕರಣಗಳು: ಟ್ರಾಕ್ಟರ್/ಟಿಲ್ಲರ್ ☐ ಎತ್ತಿನ ಬಂಡಿ ☐ ಇತರೆ ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

III. ಜೀವನೋಪಾಯಕ್ಕಾಗಿ ಗಣಿಗಾರಿಕೆ ಸಾರಿಗೆಯ ಮೇಲೆ ಅವಲಂಬನೆಯ

20. ಜೀವನೋಪಾಯಕ್ಕಾಗಿ ನಿಮ್ಮ ಕುಟುಂಬವು ಗಣಿಗಾರಿಕೆ ಸಾರಿಗೆಯನ್ನು ಅವಲಂಬಿಸಿದೆಯೇ?

ನೇರವಾಗಿ ಅವಲಂಬಿತ ☐ ಪರೋಕ್ಷವಾಗಿ ☐ ಅವಲಂಬಿತವಾಗಿಲ್ಲ ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

21. ಜೀವನೋಪಾಯದ ಮೇಲೆ ಅವಲಂಬನೆಯ ವಿಧ

ಸಾರಿಗೆ ವಾಹನ ಮಾಲೀಕರು ☐ ವಾಹನ ಕ್ಲೀನರ್/ಚಾಲಕ ☐ ಅಂಗಡಿಗಳು ☐ ಕೃಷಿ ನಷ್ಟ ☐

22. ಡಿಎಚ್ಪಿಸಿಯ ಕಾರ್ಯಾಚರಣೆಯು ನಿಮ್ಮ ಕುಟುಂಬದ ಮೇಲೆ ಯಾವುದೇ ಆರ್ಥಿಕ ಪರಿಣಾಮವನ್ನು ಬೀರುತ್ತದೆಯೇ ?

ಹೌದು ☐ ಇಲ್ಲ ☐

23. ಡಿಎಚ್ಪಿಸಿ ಯಿಂದ ಜೀವನೋಪಾಯದ ಮೇಲೆ ಪರಿಣಾಮದ ವಿಸ್ತಾರ

≤ 25% ☐ ≤50% ☐ ≤75% ☐ ≤ 100% ☐

IV. <u>ಸ್ಥಳೀಯ ಆರೋಗ್ಯದ ಮಾಹಿತಿ :</u> ಡಿಎಚ್ಪಿಸಿ ನಿರ್ಮಾಣ ಹಂತದಲ್ಲಿದೆಯೇ ☐

ಡಿಎಚ್ಪಿಸಿ ಕಾರ್ಯನಿರ್ವಹಿಸುತ್ತಿದೆಯೇ ☐

25. ಸುತ್ತಮುತ್ತಲಿನ ಪರಿಸರದ ಸ್ಥಿತಿಯ ಬಗ್ಗೆ ನಿಮ್ಮ ಅಭಿಪ್ರಾಯವೇನು?

ಅತ್ಯಂತ ಕಲುಷಿತ ☐ ಕಲುಷಿತ ☐ ಕಡಿಮೆ ಕಲುಷಿತ ☐ ಚೊಕ್ಕಟ ☐

26. ನೀವು ಆರೋಗ್ಯ ಸೌಲಭ್ಯಗಳ ಲಭ್ಯತೆಯನ್ನು ಹೊಂದಿದ್ದೀರಾ?

ಸರ್ಕಾರಿ ಆಸ್ಪತ್ರೆ ☐ ಖಾಸಗಿ ಆಸ್ಪತ್ರೆ ☐ ಖಾಸಗಿ ಚಿಕಿತ್ಸಾ ಕೇಂದ್ರಗಳು ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

27. ಕುಟುಂಬದ ಯಾವುದೇ ಸದಸ್ಯರು ಈ ಕಾಯಿಲೆಗಳಿಂದ ಬಳಲುತ್ತಿದ್ದಾರೆಯೇ?

ಶ್ವಾಸಕೋಶ ಸಮಸ್ಯೆಗಳು ☐ ಚರ್ಮದ ಸಮಸ್ಯೆಗಳು ☐

ಇತರೆ (ಯಾವುವು ---------) ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

28. ಆರೋಗ್ಯದ ಮೇಲೆ ಪರಿಣಾಮ ಬಿರಿದಿಯೇ?

ತಲೆನೋವು ☐ ನಿದ್ರೆಯ ಅಸ್ವಸ್ಥತೆ ☐

ಕಿವುಡುತನ ☐ ಇತರೆ (ಯಾವುವು ------)/ಯಾವುದೂ ಇಲ್ಲ ☐

ಸಂದರ್ಶಿಸಿದ ವ್ಯಕ್ತಿಯ ಹೆಸರು ಮತ್ತು ವಯಸ್ಸು ಸಂದರ್ಶನದ ದಿನಾಂಕ:	ಸಂದರ್ಶಕರ ಹೆಸರು ಮತ್ತು ಸಹಿ ಸಂದರ್ಶನದ ದಿನಾಂಕ:

"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:

1. General Information:

Head of the family---

Postal Address --

Village Name--

Hobli, Taluk and District---

1. Mother Tongue : □ Kannada □Telugu □ Hindi□ Other
2. No. of Family Members : -------
3. Gender : Male □ Female □
4. Family Head Education Level :□ Primary □ High School □ Degree □ None
5. Occupation of the family head :□ Farmer □ Government employee □ Private □Others

2. Economic Status:

6. Annual Income of the Family: □ < 1,00,000 /- □> 1,00,000 /-
   □ > 2,00,000 /- □ > 4,00,000 /-
7. Type of the property: □Land in hectares_______ □ Building,
   □ Vehicles, □Others (Specify: ____________)
8. Ownership of the Property: □ Own □ Joint □ Rent □ None
9. Type of house: Concrete house □ Tiles house □ Sheet house □Others
10. Electricity connection: Yes□ No□
11. Drinking water source: □ Borewell□ Surface water □ Openwell□ Others
12. Source of water for agriculture: □ Rain water □Groundwater
    □ Surface water □Others

13. Livestock information: □ Cattles □ Sheep □Chicks □Others

14. Livestock feeding information: □Forest pasture □ Planted pasture
□ Crop residues □ Purchased feed

15. Own vehicle: □ Two wheeler □ Four wheeler □Others □None

16. Fuel used for the cooking: □ LPG □Firewood
□ Biogas □ Others

17. Agricultural machinery: □ Tractor □ Bullock cart □Others □ None

3. Local Health Information:

18. Opinion on the quality of your environment
□ Highly polluted □Moderately polluted □Less polluted □ Clean

19. Health facilities in your place
□ Government Hospital □Private Hospital □Private Clinics □ None

20. Any of your family members is suffering from any illness:
□ Bronchial disease □ Skin allergy □ Others (Specify __________) □ None

4. Pipe Conveyor Transportation Information:

21. Impact on Health
□ Heavily affected □ Moderately affected □ Marginally affected □ Not affected

22. Impact on Property/ Cattles in the area
□ Heavily affected □Moderately affected □Marginally affected □ Less/Not affected

23. Impact on employment
□ High □ Moderate □ Marginal □ Did not generate

24. Whether pipe conveyor method of transportation increased the income of family?
□ High □ Moderate □ Marginal □ Less/No increase

25. Effect on agricultural productivity by pipe conveyor method of transportation
□ Heavy loss □Moderate loss□Marginal loss □ Less/No loss

5. Environment Changes in Past Ten Years:

26. Opinion about the air pollution of area
 Low Medium High Very High

27. Opinion about the water pollution of area
 Low Medium High Very High

28. Opinion about the soil pollution of area
 Low Medium High Very High

29. Opinion about the noise pollution of your area
 Low Medium High Very High

30. What is the degree of geographical landscape changes in area in recent times?
 Low Medium High Very High

31. Personal opinion on downhill pipe conveyor

-
-
-
-

32. CSR (Corporate Social Responsibility) activities carried out in the region

1. Employment training
2. Local health
3. Women empowerment
4. Others (------------------------)

Participant Name and Age:

Name of the person conducted and recorded the survey:

Date:

Surveyed by
EMPRI, Bangalore

ಅರಣ್ಯ, ಪರಿಸರ ಮತ್ತು ಹವಮಾನ ಬದಲಾವಣೆ ಸಚಿವಾಲಯ ನಿಗದಿಪಡಿಸಿದಂತೆ ಸುಧಾರಿತ ಅದಿರು ಸಾಗಾಣಿಕಾ ನಳಿಕೆಯ (JSW Downhill Pipe Conveyor) ಪರಿಸರ ಪರಿಣಾಮಗಳ ಮೌಲ್ಯಮಾಪನ

ಪರಿಸರ ನಿರ್ವಹಣೆ ಮತ್ತು ನೀತಿ ಸಂಶೋಧನಾ ಸಂಸ್ಥೆ
ಅರಣ್ಯ, ಪರಿಸರ ಮತ್ತು ಜೀವಿಶಾಸ್ತ್ರ ಇಲಾಖೆ ಕರ್ನಾಟಕ ಸರ್ಕಾರ

ಸಾಮಾಜಿಕ-ಆರ್ಥಿಕ ಸಮೀಕ್ಷೆಯ ಪ್ರಶ್ನೆಗಳು

ಅಧ್ಯಯನ ಪ್ರದೇಶ:

I. ಸಾಮಾನ್ಯ ಮಾಹಿತಿ

ಕುಟುಂಬದ ಮುಖ್ಯಸ್ಥರ ಹೆಸರು : ______________________________

ಗ್ರಾಮದ ಹೆಸರು: ______________________________

ಅಂಚೆ ವಿಳಾಸ: ______________________________

ಹೋಬಳಿ/ತಾಲ್ಲೂಕು ಮತ್ತು ಜಿಲ್ಲೆ : ______________________________

1. ಮಾತೃಭಾಷೆ: ಕನ್ನಡ ☐ ಹಿಂದಿ ☐ ತೆಲುಗು ☐ ಇತರೆ ☐

2. ಲಿಂಗ : ಸ್ತ್ರೀ ☐ ಪುರುಷ ☐

3. ಕುಟುಂಬ ಸದಸ್ಯರ ಸಂಖ್ಯೆ: ______________________________

4. ಕುಟುಂಬದ ಮುಖ್ಯಸ್ಥನ ಶಿಕ್ಷಣದ ಮಟ್ಟ:

ಪ್ರಾಥಮಿಕ ☐ ಪ್ರೌಢಶಾಲೆ ☐

ಪದವಿ ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

5. ಕುಟುಂಬದ ಮುಖ್ಯಸ್ಥನ ಉದ್ಯೋಗ: ರೈತ ☐ ಖಾಸಗಿ ☐

ಸರ್ಕಾರಿ ಉದ್ಯೋಗಿ ☐ ಇತರೆ ☐

II. ಆರ್ಥಿಕ ಸ್ಥಿತಿ

6. ಕುಟುಂಬದ ಮುಖ್ಯಸ್ಥನ ವಾರ್ಷಿಕ ಆದಾಯ:

< 1,00,000 /- ☐ > 1,00,000 /- ☐

> 2,00,000/- ☐ > 4,00,000 /- ☐

7. ಆಸ್ತಿಯ ವಿಧ : ಸ್ವಂತ ಭೂಮಿ ☐ (ವಿಸ್ತಾರ (ಎಕರೆಗಳಲ್ಲಿ): -------------)

ಕಟ್ಟಡ ☐ ವಾಹನ ☐ ಇತರೆ ☐

8. ಆಸ್ತಿ ಮಾಲೀಕತ್ವ: ವೈಯಕ್ತಿಕ ☐ ಜಂಟಿ ☐ ಬಾಡಿಗೆ ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

9. ಮನೆ: ಕಾಂಕ್ರೀಟ್ ಮನೆ ☐ ಹೆಂಚಿನ ಮನೆ ☐

ಶೀಟ್ ಮನೆ ☐ ಇತರೆ ☐

10. ವಿದ್ಯುತ್ ಸಂಪರ್ಕ: ಇದೆ ☐ ಇಲ್ಲ ☐

11. ಕುಡಿಯುವ ನೀರಿನ ಮೂಲ: ಬೋರ್ ವೆಲ್ ☐ ಮೇಲ್ಮೈನೀರು ☐

ತೆರೆದಬಾವಿ ☐ ಇತರೆ ☐

12. ಕೃಷಿಗೆ ನೀರಿನ ಮೂಲ: ಮಳೆ ನೀರು ☐ ಅಂತರ್ಜಲ ☐

ಮೇಲ್ಮೈ ನೀರು ☐ ಇತರೆ ☐

13. ಜಾನುವಾರಗಳ ಮಾಹಿತಿ: ಹಸು ☐ ಕುರಿ ☐ ಕೋಳಿ ☐ ಇತರೆ ☐

14. ಜಾನುವಾರುಗಳ ಆಹಾರ: ನೈಸರ್ಗಿಕ ಹುಲ್ಲು ☐ ನೆಟ್ಟ ಹುಲ್ಲು ☐

ಬೆಳೆ ಉಳಿಕೆಗಳು ☐ ಖರೀದಿಸಿದ ಆಹಾರ ☐

15. ಸ್ವಂತ ವಾಹನಗಳು: ದ್ವಿಚಕ್ರ ☐ ನಾಲ್ಕುಚಕ್ರ ☐

ಇತರೆ ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

16. ಅಡುಗೆ ಮಾಡಲು ಬಳಸುವ ಇಂಧನ ಪ್ರಕಾರ:

LPG ಸಿಲಿಂಡರ್ ☐ ಕಟ್ಟಿಗೆ ☐ ಜೈವಿಕ ಅನಿಲ ☐ ಇತರೆ ☐

17. ಕೃಷಿ ಉಪಕರಣಗಳು:

ಟ್ರಾಕ್ಟರ್/ಟಿಲ್ಲರ್ ☐ ಎತ್ತಿನ ಬಂಡಿ ☐

ಇತರೆ ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

III. <u>ಸ್ಥಳೀಯ ಆರೋಗ್ಯದ ಮಾಹಿತಿ</u>

18. ಸುತ್ತಮುತ್ತಲಿನ ಪರಿಸರದ ಸ್ಥಿತಿಯ ಬಗ್ಗೆ ನಿಮ್ಮ ಅಭಿಪ್ರಾಯವೇನು?

ಅತ್ಯಂತ ಕಲುಷಿತ ☐ ಕಲುಷಿತ ☐

ಕಡಿಮೆ ಕಲುಷಿತ ☐ ಚೊಕ್ಕಟ ☐

19. ನೀವು ಆರೋಗ್ಯ ಸೌಲಭ್ಯಗಳ ಲಭ್ಯತೆಯನ್ನು ಹೊಂದಿದ್ದೀರಾ?

ಸರ್ಕಾರಿ ಆಸ್ಪತ್ರೆ ☐ ಖಾಸಗಿ ಆಸ್ಪತ್ರೆ ☐

ಖಾಸಗಿ ಚಿಕಿತ್ಸಾ ಕೇಂದ್ರಗಳು ☐ ಯಾವುದೂ ಇಲ್ಲ ☐

20. ಕುಟುಂಬದ ಯಾವುದೇ ಸದಸ್ಯರು ಈ ಕಾಯಿಲೆಗಳಿಂದ ಬಳಲುತ್ತಿದ್ದಾರೆಯೇ ?

ಶ್ವಾಸಕೋಶ ಸಮಸ್ಯೆಗಳು ☐ ಚರ್ಮದ ಸಮಸ್ಯೆಗಳು ☐

ಇತರೆ (ಯಾವುವು ------) ಯಾವುದೂ ಇಲ್ಲ ☐

IV. <u>ಗಣಿ ಮತ್ತು ಸುಧಾರಿತ ಅದಿರು ಸಾಗಾಣಿಕೆ ಕುರಿತ ಮಾಹಿತಿ</u>

21. ಆರೋಗ್ಯದ ಮೇಲೆ ಪರಿಣಾಮ

ಭಾರೀ ಪರಿಣಾಮ ☐ ಮಧ್ಯಮ ಪರಿಣಾಮ ☐

ಕನಿಷ್ಠ ಪರಿಣಾಮ ☐ ಪರಿಣಾಮವಿಲ್ಲ ☐

22. ಆಸ್ತಿ/ ಜಾನು ವಾರುಗಳ ಮೇಲೆ ಪರಿಣಾಮ

ಭಾರೀ ಪರಿಣಾಮ ☐ ಮಧ್ಯಮ ಪರಿಣಾಮ ☐

ಕನಿಷ್ಠ ಪರಿಣಾಮ ☐ ಕಡಿಮೆ/ಪರಿಣಾಮವಿಲ್ಲ ☐

23. ಉದ್ಯೋಗದ ಮೇಲೆ ಪರಿಣಾಮ

ಹೆಚ್ಚು ☐ ಮಧ್ಯಮ ☐

ಕನಿಷ್ಠ ☐ ಸೃಷ್ಟಿಸಲಿಲ್ಲ ☐

24. ಪೈಪ್ ಕನ್ವೇಯರ್ನಿಂದ ಕುಟುಂಬದ ಆದಾಯ ಮೇಲೆ ಪರಿಣಾಮ

ಹೆಚ್ಚು ☐ ಮಧ್ಯಮ ☐

ಕನಿಷ್ಠ ☐ ಕಡಿಮೆ / ಹೆಚ್ಚಳವಿಲ್ಲ ☐

25. ಪೈಪ್ ಕನ್ವೇಯರ್ನಿಂದ ಬೆಳೆಯ ಮೇಲೆ ಪರಿಣಾಮ

ಭಾರೀ ನಷ್ಟ ☐ ಮಧ್ಯಮ ನಷ್ಟ ☐

ಕನಿಷ್ಠ ನಷ್ಟ ☐ ಕಡಿಮೆ ನಷ್ಟ/ ನಷ್ಟವಿಲ್ಲ ☐

<u>V. ಕಳೆದ ಹತ್ತು ವರ್ಷಗಳಲ್ಲಿ ಇಲ್ಲಿನ ಪರಿಸರದಲ್ಲಾಗಿರುವ ಬದಲಾವಣೆಗಳು</u>

26. ವಾಯು ಮಾಲಿನ್ಯ

ಅತೀ ಹೆಚ್ಚು ☐ ಹೆಚ್ಚು ☐ ಮಧ್ಯಮ ☐ ಕಡಿಮೆ ☐

27. ಜಲಮಾಲಿನ್ಯ

ಅತೀ ಹೆಚ್ಚು ☐ ಹೆಚ್ಚು ☐ ಮಧ್ಯಮ ☐ ಕಡಿಮೆ ☐

28. ಮಣ್ಣಿನ ಮಾಲಿನ್ಯ

ಅತೀ ಹೆಚ್ಚು ☐ ಹೆಚ್ಚು ☐ ಮಧ್ಯಮ ☐ ಕಡಿಮೆ ☐

29. ಶಬ್ದ ಮಾಲಿನ್ಯ

ಅತೀ ಹೆಚ್ಚು ☐ ಹೆಚ್ಚು ☐ ಮಧ್ಯಮ ☐ ಕಡಿಮೆ ☐

30. ಇತ್ತೀಚಿನ ದಿನಗಳಲ್ಲಿ ನಿಮ್ಮ ಸುತ್ತಲಿನ ಪರಿಸರದಲ್ಲಿ ಆದಂತಹ ಭೌಗೋಳಿಕ ಬದಲಾವಣೆಗಳ

ಪರಿಣಾಮ ಎಷ್ಟಿರಬಹುದು

ಅತೀ ಹೆಚ್ಚು ☐ ಹೆಚ್ಚು ☐ ಮಧ್ಯಮ ☐ ಕಡಿಮೆ ☐

31. ಡೌನ್ ಹಿಲ್ ಪೈಪ್ ಕನ್ವೇಯರ್ ನ ಬಗ್ಗೆ ನಿಮ್ಮ ಅಭಿಪ್ರಾಯಗಳೇನು?

-
-
-

32. ನಿಮ್ಮ ಸುತ್ತಲಿನ ಪ್ರದೇಶದಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾದ ಸಿ ಎಸ್ ಆರ್ (ಕಾರ್ಪೊರೇಟ್ ಸೋಷಿಯಲ್ ರೆಸ್ಪಾನ್ಸಿಬಲಿಟಿ) ಚಟುವಟಿಕೆಗಳು

1. ಉದ್ಯೋಗ ತರಬೇತಿ
2. ಸ್ಥಳೀಯ ಆರೋಗ್ಯ
3. ಮಹಿಳಾ ಸಬಲೀಕರಣ
4. ಇತರೆ (----------------------)

ಸಂದರ್ಶಿಸಿದ ವ್ಯಕ್ತಿಯ ಹೆಸರು ಮತ್ತು ವಯಸ್ಸು ----------------------------------

ಸಂದರ್ಶಕರ ಹೆಸರು :

ಸಂದರ್ಶನದ ದಿನಾಂಕ :

ಮಾಹಿತಿ ಸಂಗ್ರಹಣೆ
ಎಂಪ್ರಿ
ಬೆಂಗಳೂರು

ANNEXURE – IV

Secondary data of meteorological monitoring – Devadari, Tunga & Bhadra and Rama DHPC

(Season I)

March - 2021

Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Mar-21	604.15	30.61	26.48	38.35	31.03.2021	21.15	06.03.2021	75.74	10.29	30.79

Month	Solar Radiation			Rainfall						Mean wind speed	Evp. Rate	Cloud Index
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year			
	W/m2	W/m2	W/m2	mm		mm	mm	mm		Km/hour	cm	
Mar-21	11.38	793.49	584	0	0	0	0.6	1.5	06.01.2021	6.9	-	-

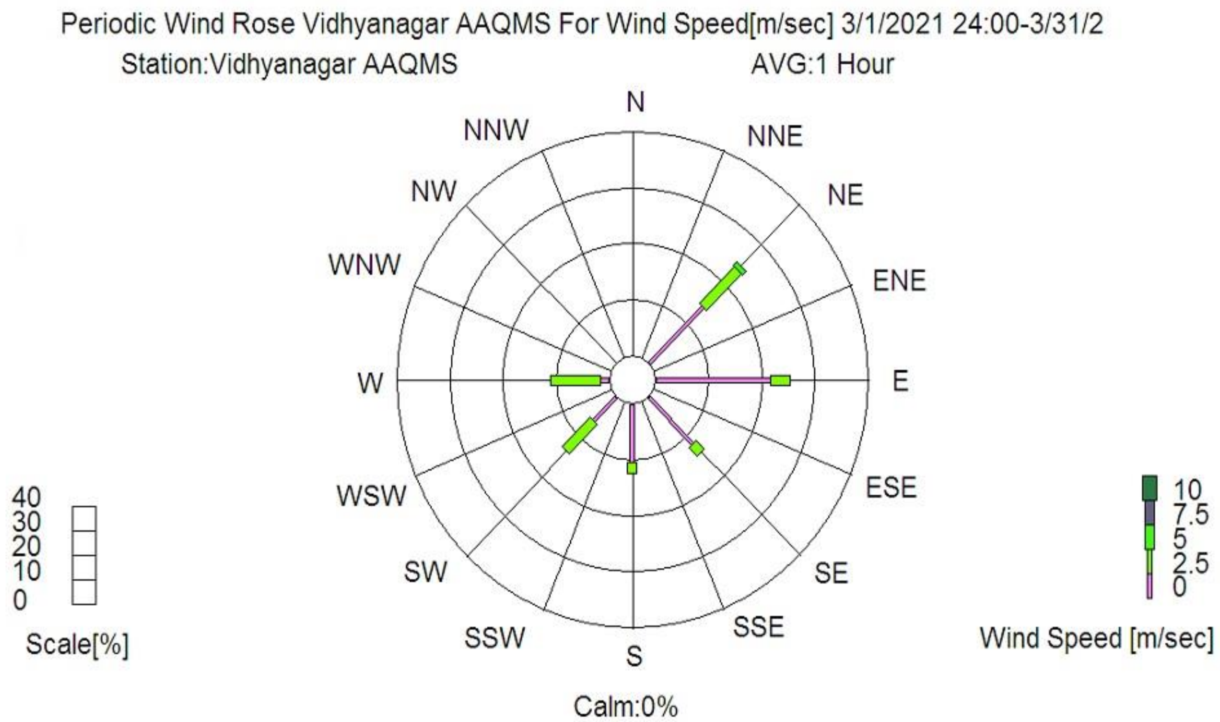


Figure 1 - Wind rose diagram - March 2021

April - 2021

Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Apr-21	601.42	33.55	26.21	39.37	07.04.2021	21.14	29.04.2021	82.46	11.24	42.03

Month	Solar Radiation			Rainfall						Mean wind speed	Evp. Rate	Cloud Index
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year			
	W/m2	W/m2	W/m2	mm		mm	mm	mm		Km/hour	cm	
Apr-21	11.89	708.44	361.26	0	0	0	19.1	9.5	21.04.2021	7.7		

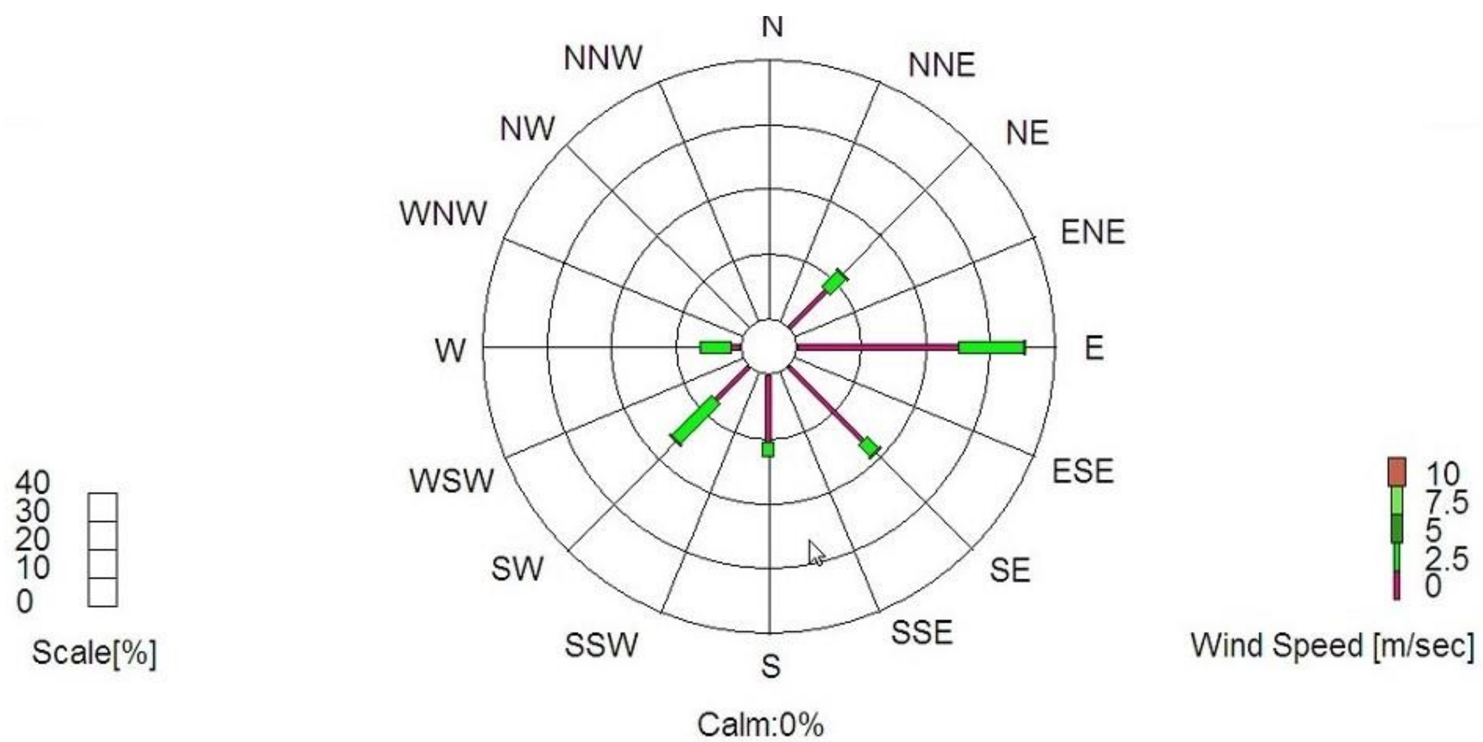


Figure 2- Wind rose diagram - April 2021

May - 2021

Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg
	millibar	deg. C	deg.C	deg.C		deg.C		%	%	%
May-21	609	31.21	25.9	36.68	03.05.2021	22.08	07.05.2021	94.08	22.23	55.81

Month	Solar Radiation			Rainfall						Mean wind speed	Evp. Rate	Cloud Index
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year			
	W/m2	W/m2	W/m2	mm		mm	mm	mm		Km/hour	cm	
May-21	11.86	910	248	68.5	7	112	19.1	32	21.05.2021	8.53	-	-

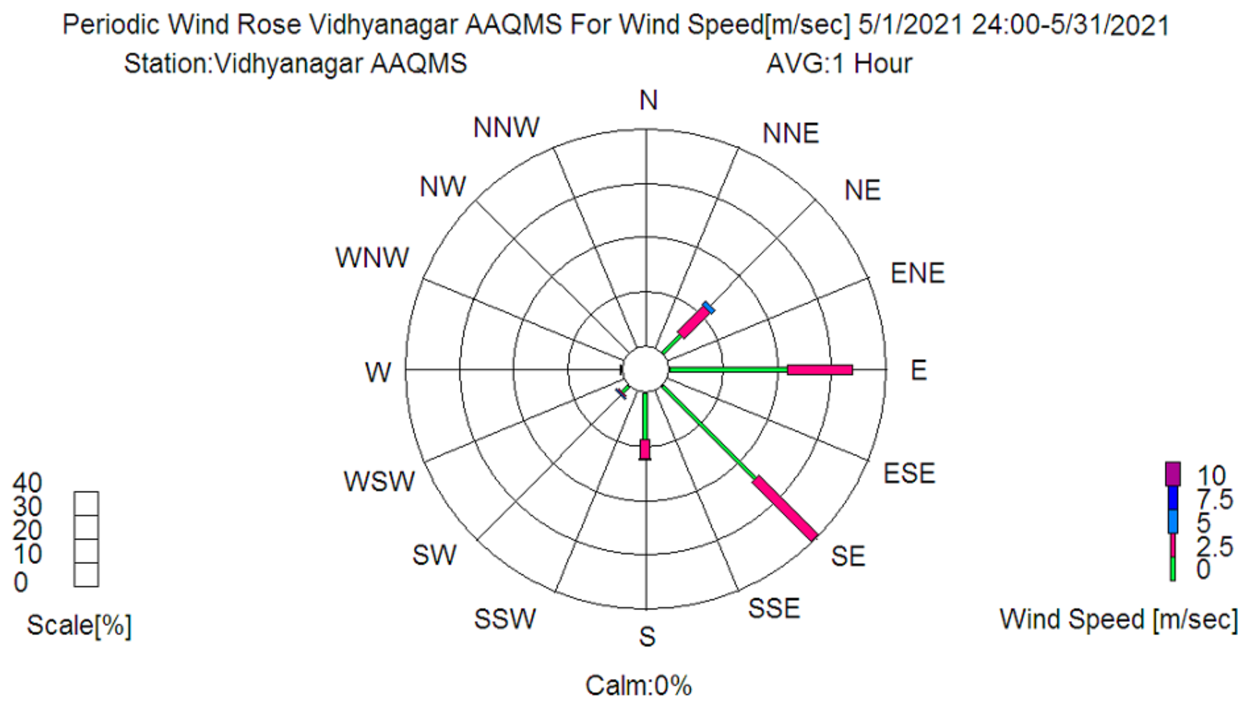


Figure 3- Wind rose diagram – May 2021

3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1 & Figure 3.1.**

SUMMARY OF MICROMETEOROLOGICAL DATA

TABLE-3.1

July-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg. C	deg.C	deg.C		deg.C		%	%	%
Jul-21	601.42	34.83	22.77	34.83	04.07.2021	22.77	14.07.2021	95.81	88.12	81.24

Month	Solar Radiation			Rainfall			
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Mean wind speed
	W/m²	W/m²	W/m²	mm		mm	Mm
July-21	12.15	1198.01	326.08	116	11	0	5.58

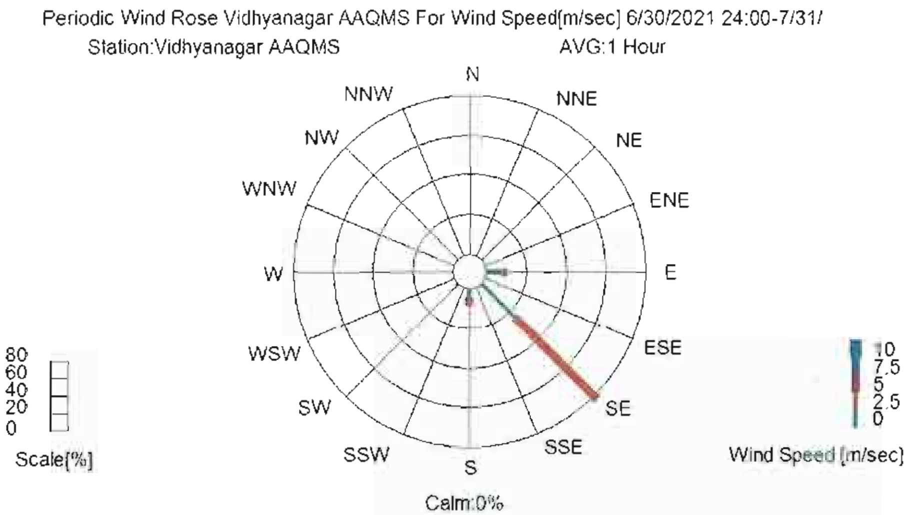


Figure 1.3 Windrose Diagram

3.2 Ambient Air Quality Observations

Summary of the ambient air quality (AAQ) at each location is given in Following table and data is given in **Annexure-I** and summary is given in **table 3.2**

SUMMARY OF AAQ

TABLE-3.2

S. No.	LOCATIONS	Concentration											
		μg/m³								mg/m³		μg/m³	
		RPM (PM_{10})		$PM_{2.5}$		SO_2		NO_2		CO		Fe	
		Max	Min	Max	Min	Max	CO	Max	Min	Max	Min	Max	Min
1	Core Zone (Within 500 m from the mine lease area)	80	73	47	40	15.9	14.8	24	23.1	0.72	0.65	1.2	0.4
2	Taranagar	81	76	50	45	16.3	15.5	21.3	20.5	0.8	0.75	BDL	
3	Bannihatti	80	73	50	40	17.2	15.6	25	23.9	0.85	0.7	BDL	
4	Lingadahalli	79	73	41	37	15.8	15.2	19.7	18	0.79	0.7	BDL	
5	Muraripura	79	67	44	35	15.8	14.9	19.5	18.3	0.78	0.69	BDL	
NAAQ Standards for Industrial, Residential, Rural and Other Areas		100		60		80		80		2.0 (8 hourly)		-	

3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1 & Figure 3.1.**

SUMMARY OF MICROMETEOROLOGICAL DATA
TABLE-3.1

August-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg. C	deg.C	deg.C		deg.C		%	%	%
Aug-21	601.61	33.32	22.00	33.32	08.08.2021	22.00	29.08.2021	93.47	41.3	68.84

Month	Solar Radiation			Rainfall			
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Mean wind speed
	W/m2	W/m2	W/m2	mm		mm	Mm
Aug-21	12.52	1285.14	366.35	122	13	0	2.36

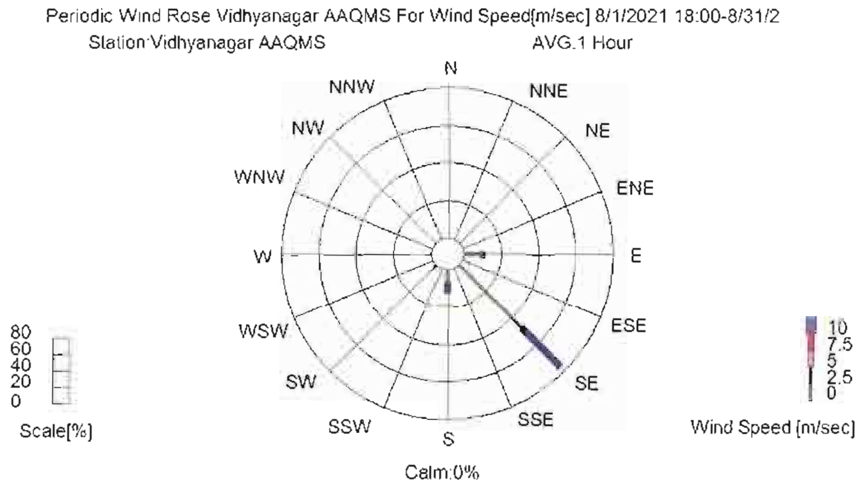


Figure 1.3 Windrose Diagram

3.2 Ambient Air Quality Observations

Summary of the ambient air quality (AAQ) at each location is given in Following table and data is given in **Annexure-I** and summary is given in **table 3.2**

SUMMARY OF AAQ

TABLE-3.2

S.No.	LOCATIONS	Concentration									
		µg/m³								mg/m³	
		RPM (PM_{10})		$PM_{2.5}$		SO_2		NO_2		CO	
		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	Core Zone (Within 500 m from the mine lease area)	83	75	49	42	16.2	14.9	24.3	23.3	0.74	0.67
2	Taranagar	84	78	51	47	16.5	16.1	21.4	21	0.83	0.77
3	Bannihatti	85	76	53	43	17.4	16	25.2	24.1	0.83	0.73
4	Lingadahalli	81	74	47	38	16	15.4	19.7	18	0.82	0.73
5	Muraripura	81	69	46	37	16	15.1	19.7	18.4	0.8	0.71
NAAQ Standards for Industrial, Residential, Rural and Other Areas		100		60		80		80		2.0 (8 hourly)	

3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1 & Figure 3.1.**

SUMMARY OF MICROMETEOROLOGICAL DATA
TABLE-3.1

September-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Sept-21	598	27.2	20.1	29.98	21.09.2021	17.1	28.09.2021	96.32	20.75	65.64

Month	Solar Radiation			Rainfall						Mean wind speed	Evp. Rate	Cloud Index
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in month	Date & Year			
	W/m^2	W/m^2	W/m^2	mm		mm	mm	mm		Km/h	cm	
Sept-21	11.31	602	298	26.1	10	235.6	9	53	16.09.2021	12.36	-	-

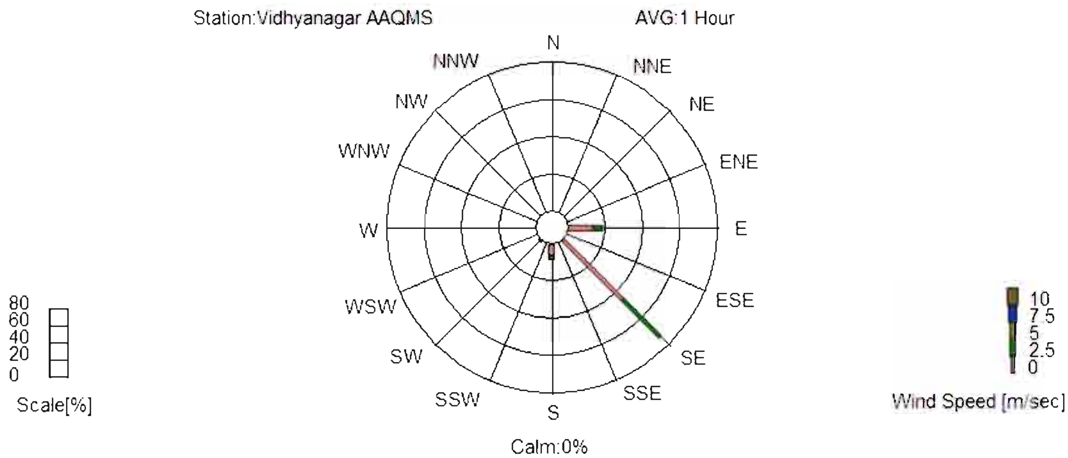


Figure 1.3 Windrose Diagram

3.2 Ambient Air Quality Observations

Summary of the ambient air quality (AAQ) at each location is given in Following table and data is given in **Annexure-I** and summary is given in **table 3.2**

SUMMARY OF AAQ
TABLE-3.2

S.No.	LOCATIONS	Concentration									
		μg/m³								mg/m³	
		RPM (PM_{10})		$PM_{2.5}$		SO_2		NO_2		CO	
		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	Core Zone (Within 500 m from the mine lease area)	82	73	49	42	16.2	15	24.3	23.2	0.73	0.67
2	Taranagar	84	79	52	45	16.6	15.9	21.5	20.8	0.84	0.75
3	Bannihatti	85	77	53	41	17.5	16.1	25.2	24.1	0.82	0.75
4	Lingadahalli	83	76	48	39	16.2	15.2	19.5	18.2	0.81	0.72
5	Muraripura	82	71	48	36	16.2	15.1	19.8	18.5	0.83	0.75
NAAQ Standards for Industrial, Residential, Rural and Other Areas		**100**		**60**		**80**		**80**		**2.0 (8 hourly)**	

3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

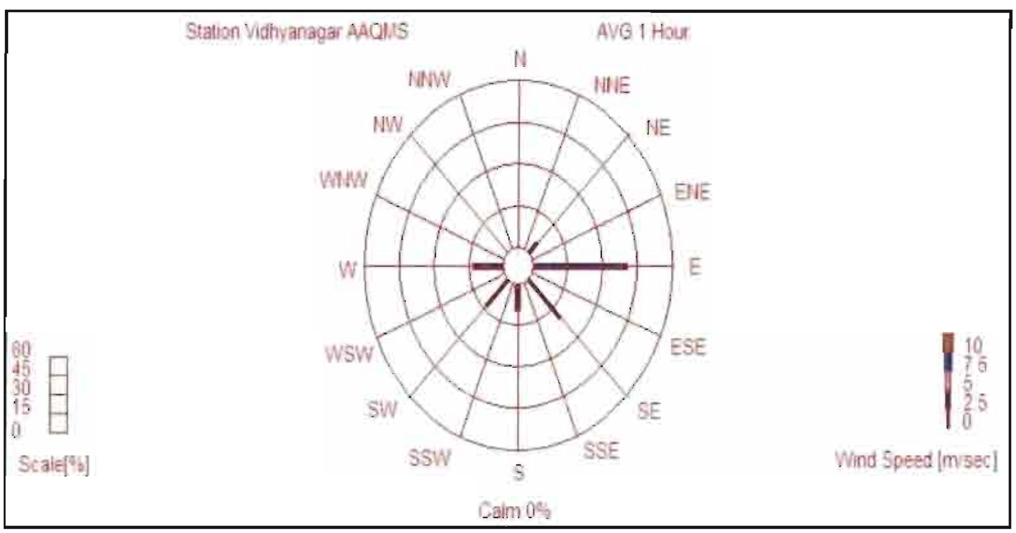
TABLE-3.1

Summary of micrometeorological data

October-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Oct-21	1009.72	32.8	19.5	32.76	23.10.2021	19.48	28.10.2021	93.48	33.04	68.9

Month	Solar Radiation			Rainfall						Mean wind speed
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year	
	W/m2	W/m2	W/m2	mm		mm	mm	mm		m/s
Oct-21	0	1810.77	286.93	131.5	14	379	19.1	43.5	02.10.2021	1.63

FIGURE 1.3 Windrose Diagram



3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

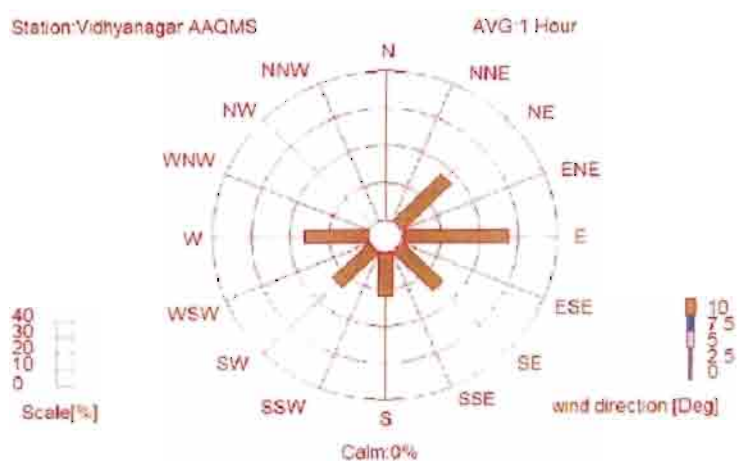
TABLE-3.1

Summary of micrometeorological data

Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Nov-21	935.02	29.83	19.53	29.83	23.11.2021	19.53	09.11.2021	93.26	34.8	95

	Solar Radiation			Rainfall						Mean wind speed
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year	
	W/m2	W/m2	W/m2	mm		mm	mm	mm		m/s
Nov-21	0	1810.77	286.93	131.5	14	379	19.1	43.5	02.10.2021	1.63

FIGURE 1.3 Windrose Diagram



3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data is shown in **Table 3.1**

TABLE-3.1

Summary of micrometeorological data

July – 2021										
		Air temperature						Humidity		
		Mean of		Extremes						
Month	Station level pressure	Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Jul-21	601.42	34.83	22.77	34.83	04.07.2021	22.77	14.07.2021	95.81	88.12	81.24

	Solar Radiation			Rainfall								
Month	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in month	Date & Year	Mean wind speed	Evp. Rate	Cloud Index
	W/m²	W/m²	W/m²	mm		mm	Mm	mm		km/h	Cm	
Jul-21	12.15	1198.01	326.08	116	11	0	23	26.5	02.07.2021	5.58	-	-

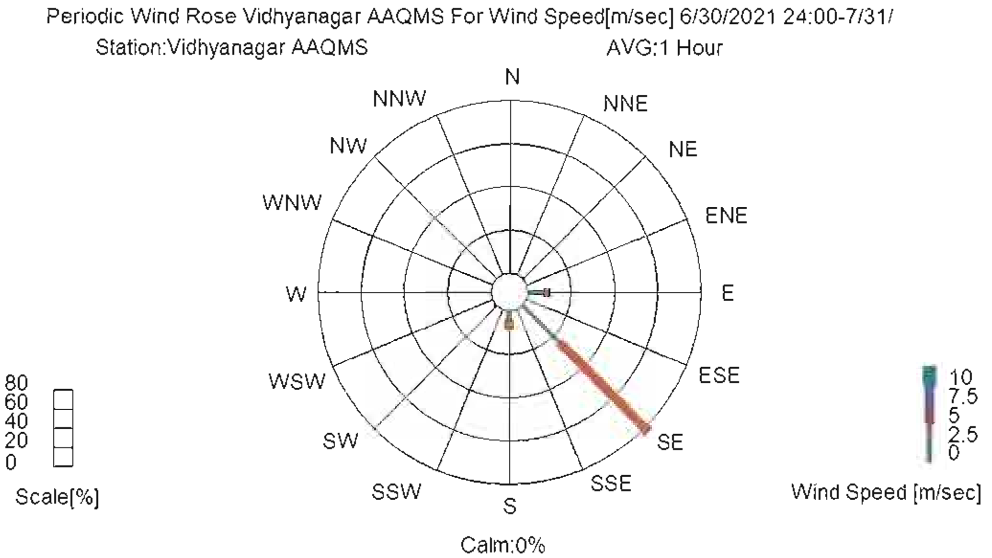


FIG. 1.3: WINDROSE DIAGRAM

33.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

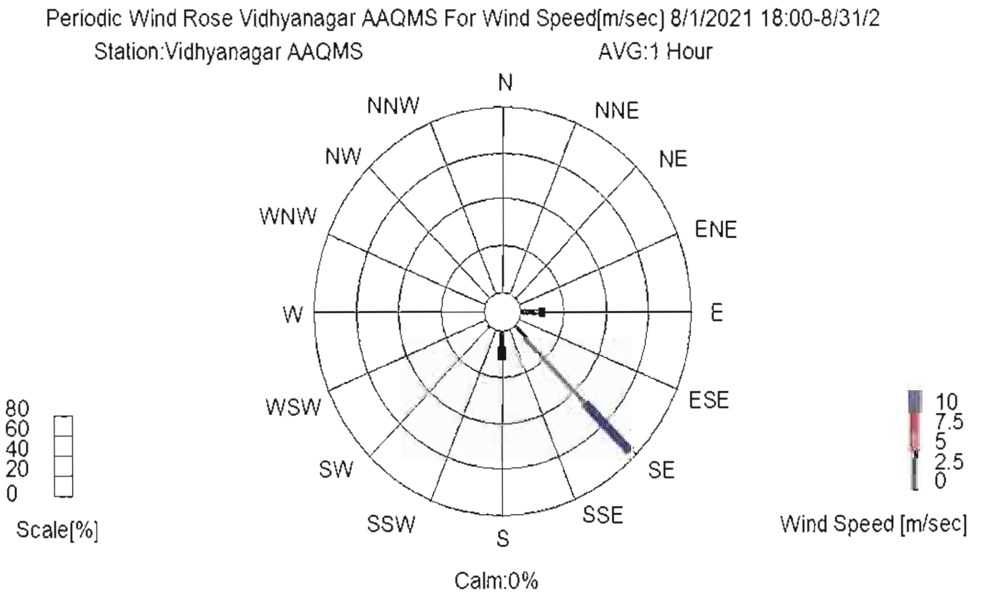
TABLE-3.1

Summary of micrometeorological data

August-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Aug-21	601.61	33.32	22.00	33.32	08.08.2021	22.00	29.08.2021	93.47	41.3	68.84

Month	Solar Radiation			Rainfall			Mean wind speed
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	
	W/m²	W/m²	W/m²	mm		mm	Km/h
Aug-21	12.52	1285.14	366.35	122	13	0	2.36

FIGURE 1.3 Windrose Diagram



3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

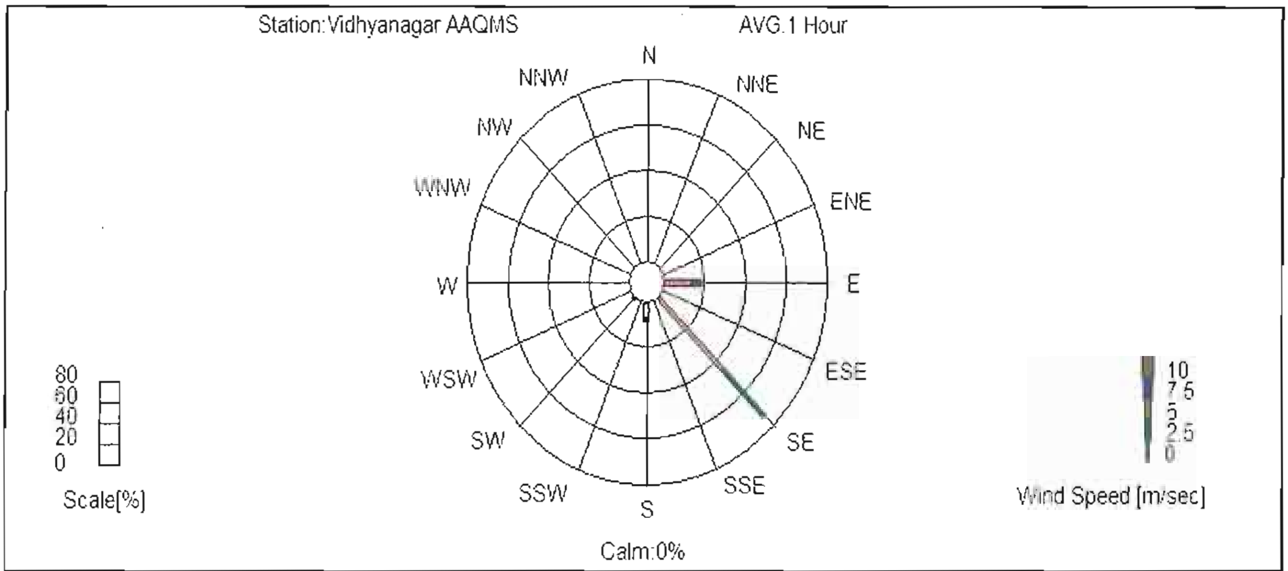
TABLE-3.1

Summary of micrometeorological data

September-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Sep-21	598	27.2	20.1	29.98	21.09.2021	17.1	28.09.2021	96.32	20.75	65.64

Month	Solar Radiation			Rainfall						Mean wind speed
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year	
	W/m2	W/m2	W/m2	mm		mm	mm	mm		Km/hour
Sep-21	11.31	602	298	26.1	10	235.6	9	53	16.09.2021	12.36

FIGURE 1.3 Windrose Diagram



3. 0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

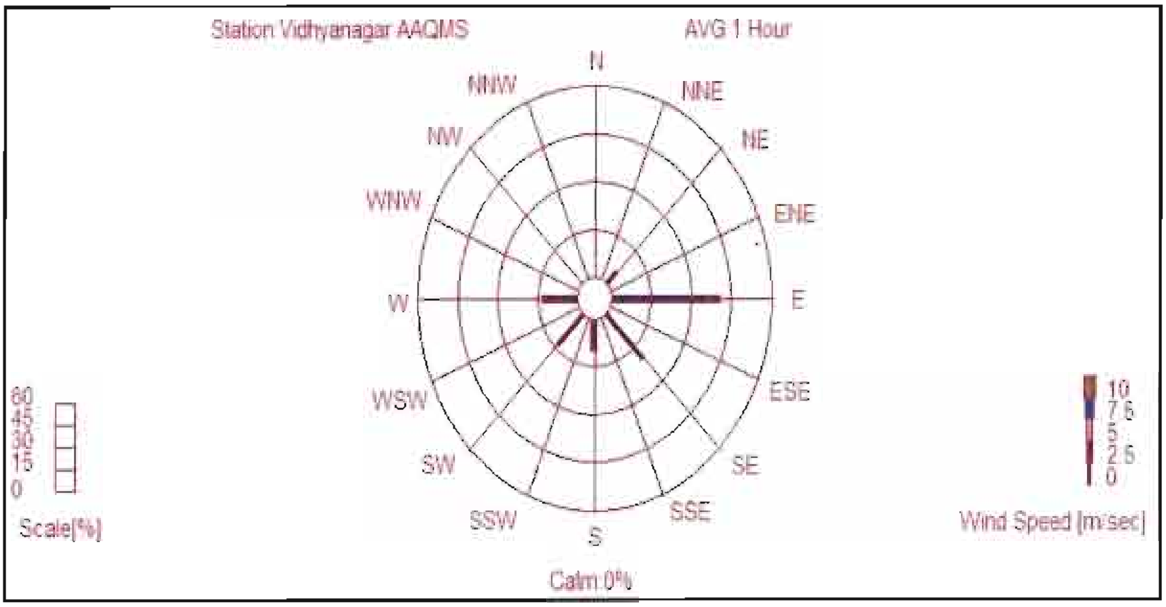
TABLE-3.1

Summary of micrometeorological data

October-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Oct-21	1009.72	32.8	19.5	32.76	23.10.2021	19.48	28.10.2021	93.48	33.04	68.9

Month	Solar Radiation			Rainfall						Mean wind speed
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year	
	W/m2	W/m2	W/m2	mm		mm	mm	mm		m/s
Oct-21	0	1810.77	286.93	131.5	14	379	19.1	43.5	02.10.2021	1.63

FIGURE 1.3 Windrose Diagram



3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

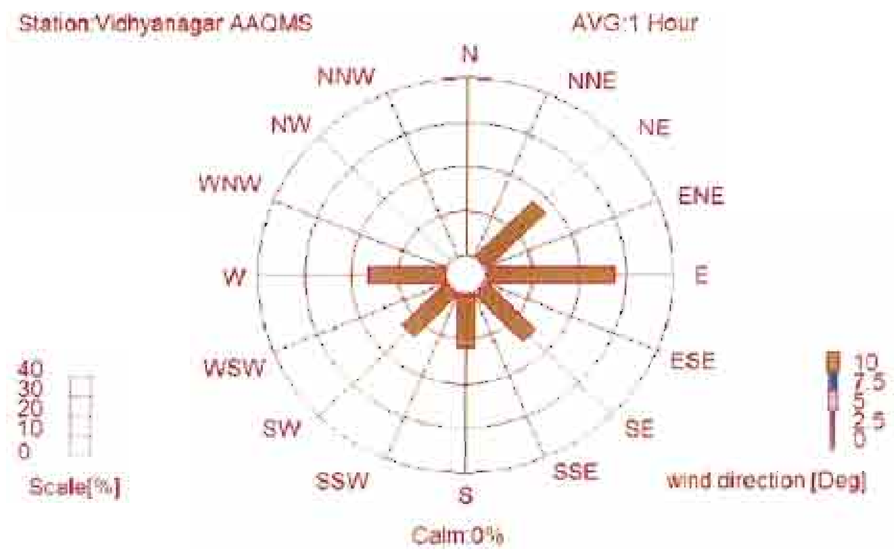
TABLE-3.1

Summary of micrometeorological data

Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Nov-21	935.02	29.83	19.53	29.83	23.11.2021	19.53	09.11.2021	93.26	34.8	95

Month	Solar Radiation			Rainfall						Mean wind speed
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year	
	W/m2	W/m2	W/m2	mm		mm	mm	mm		m/s
Nov-21	0	1810.77	286.93	131.5	14	379	19.1	43.5	02.10.2021	1.63

FIGURE 1.3 Windrose Diagram



3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

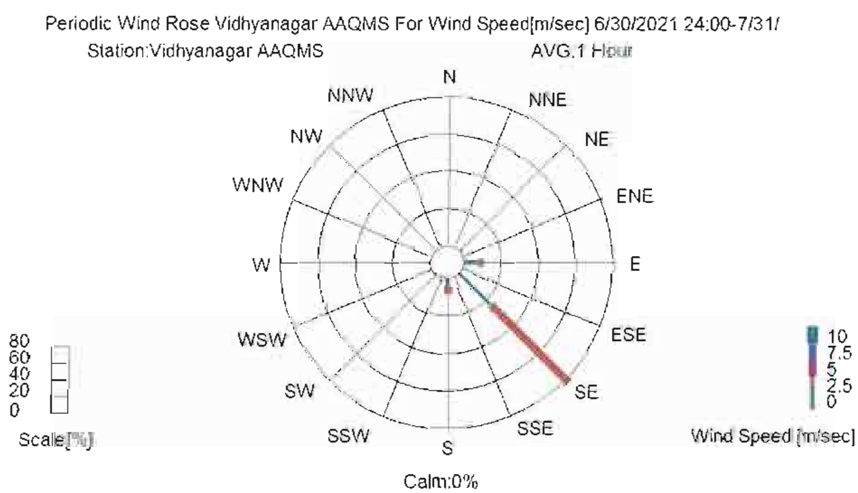
TABLE-3.1

Summary of micrometeorological data

July-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg. C	deg.C	deg.C		deg.C		%	%	%
Jul-21	601.42	34.83	22.77	34.83	04.07.2021	22.77	14.07.2021	95.81	88.12	81.24

Month	Solar Radiation			Rainfall			
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Mean wind speed
	W/m²	W/m²	W/m²	mm		mm	Mm
July-21	12.15	1198.01	326.08	116	11	0	5.58

FIGURE 1.3 Windrose Diagram



3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

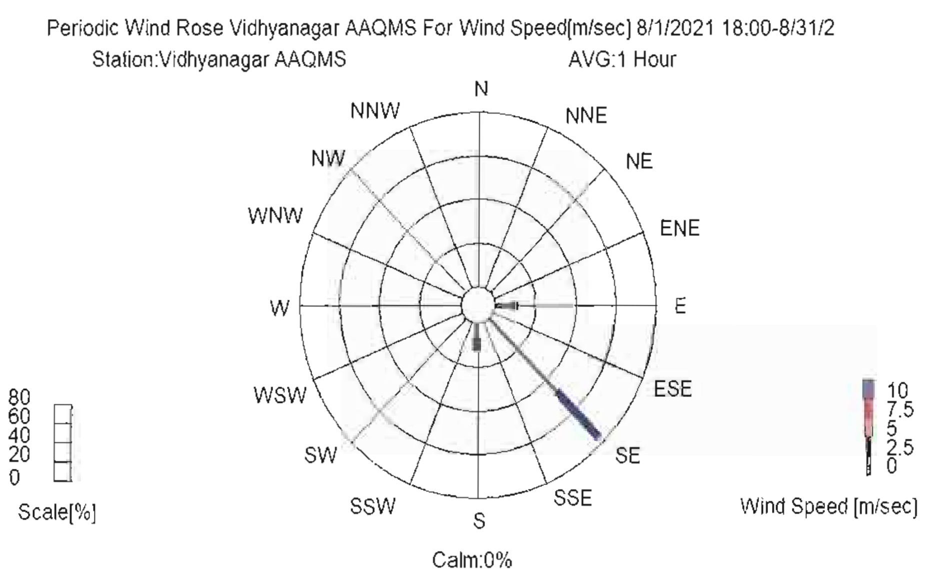
TABLE-3.1

Summary of micrometeorological data

August-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Aug-21	601.61	33.32	22.00	33.32	08.08.2021	22.00	29.08.2021	93.47	41.3	68.84

Month	Solar Radiation			Rainfall			Mean wind speed
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	
	W/m²	W/m²	W/m²	mm		mm	Km/h
Aug-21	12.52	1285.14	366.35	122	13	0	2.36

FIGURE 1.3 Windrose Diagram



3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

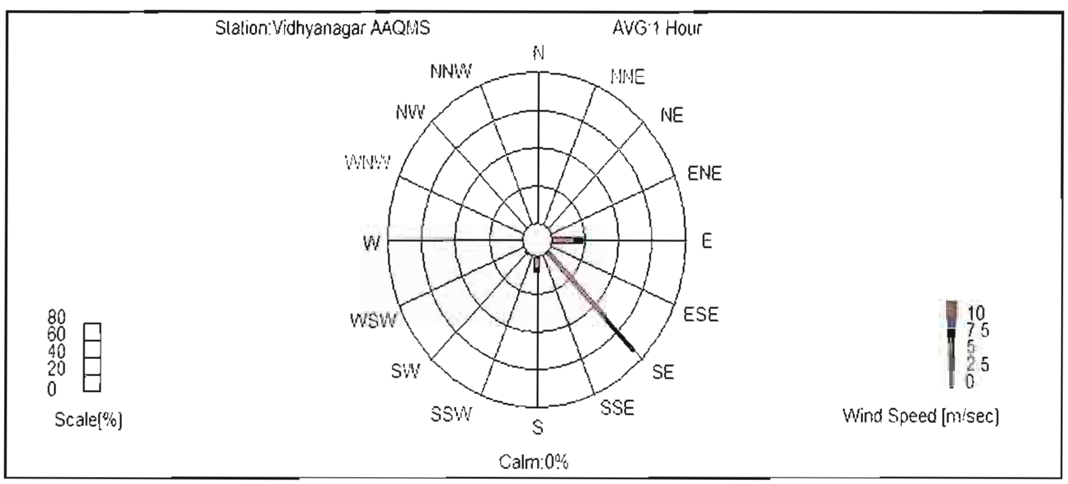
TABLE-3.1

Summary of micrometeorological data

September-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Sep-21	598	27.2	20.1	29.98	21.09.2021	17.1	28.09.2021	96.32	20.75	65.64

Month	Solar Radiation			Rainfall						Mean wind speed
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year	
	W/m2	W/m2	W/m2	mm		mm	mm	mm		Km/hour
Sep-21	11.31	602	298	26.1	10	235.6	9	53	16.09.2021	12.36

FIGURE 1.3 Windrose Diagram



3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

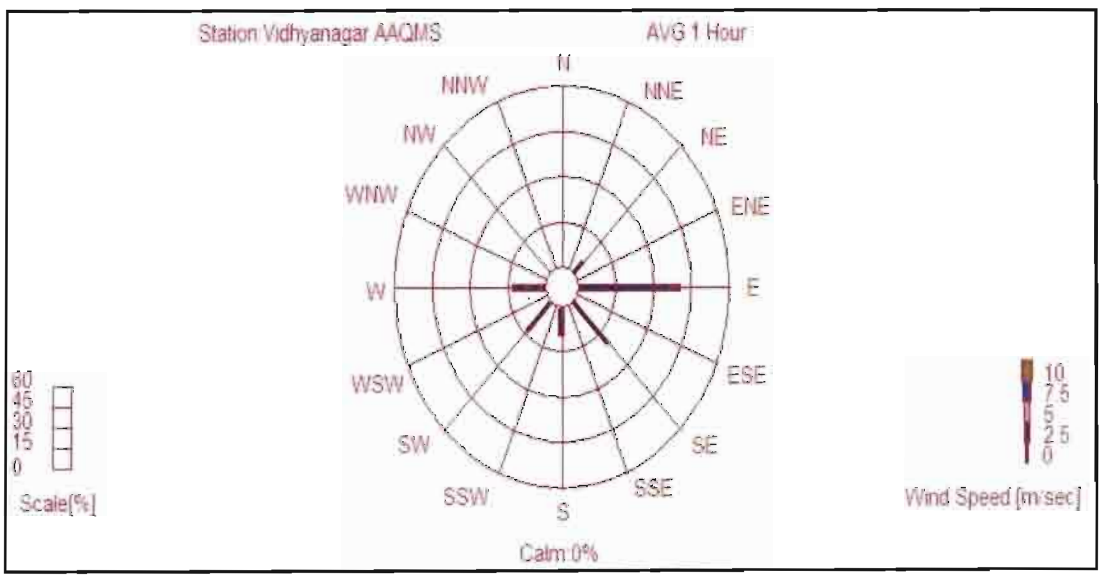
TABLE-3.1

Summary of micrometeorological data

October-2021										
Month	Station level pressure	Air temperature						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg.
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Oct-21	1009.72	32.8	19.5	32.76	23.10.2021	19.48	28.10.2021	93.48	33.04	68.9

Month	Solar Radiation			Rainfall						Mean wind speed
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year	
	W/m2	W/m2	W/m2	mm		mm	mm	mm		m/s
Oct-21	0	1810.77	286.93	131.5	14	379	19.1	43.5	02.10.2021	1.63

FIGURE 1.3 Windrose Diagram



3.0 DATA ANALYSIS

3.1 Meteorology

The details of Meteorological data are shown in **Table 3.1**

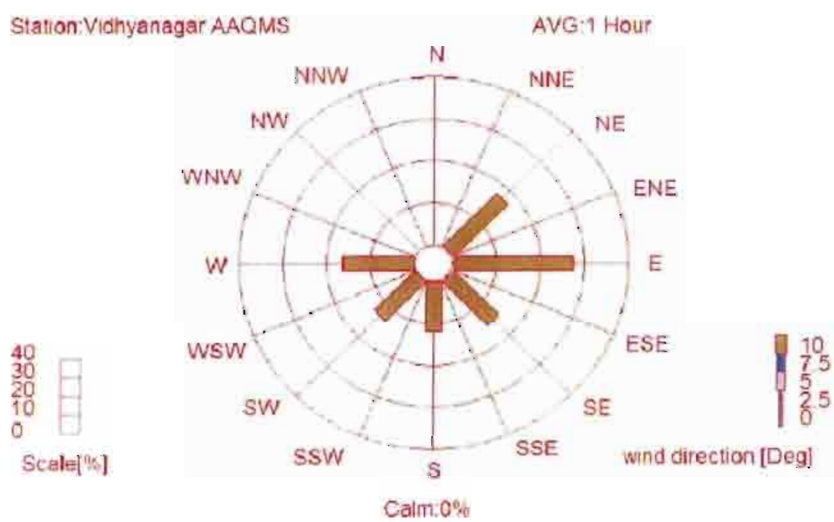
TABLE-3.1

Summary of micrometeorological data

Month	Station level pressure	**Air temperature**						Humidity		
		Mean of		Extremes						
		Daily max	Daily min	Highest in the month	Date & Year	Lowest in the month	Date & Year	Max	Min	Avg
	millibar	deg.C	deg.C	deg.C		deg.C		%	%	%
Nov-21	935.02	29.83	19.53	29.83	23.11.2021	19.53	09.11.2021	93.26	34.8	95

Month	**Solar Radiation**			**Rainfall**						Mean wind speed
	Min	Max	Avg	Monthly total	No of rainy days in month	Total in wettest month	Total in driest month	Heaviest fall in year	Date & Year	
	W/m2	W/m2	W/m2	mm		mm	mm	mm		m/s
Nov-21	0	1810.77	286.93	131.5	14	379	19.1	43.5	02.10.2021	1.63

FIGURE 1.3 Windrose Diagram



ANNEXURE – V

Field Photographs – Season I

Surface water sampling

Groundwater sampling

Soil sampling

Ambient Air Quality monitoring

Ambient Noise Quality monitoring

Socio-economic survey

Field Photographs – Season II

Ambient Air Quality monitoring

Ambient Noise Quality monitoring

Surface water sampling


Groundwater sampling

Sample preservation

Onsite analysis


Soil sampling


Socio economic survey


Meteorological stations at M/s Tunga & Bhadra and Devadari Iron ore mines


Laboratory analysis

Field Photographs – Season III

	
Surface water sampling and preservation	
	
Ambient Air Quality monitoring	
	
Groundwater sampling and preservation	


Ambient Noise Quality monitoring


Soil sampling


Socio-economic survey

Meteorological station at M/s Rama Iron ore mines

Laboratory analysis