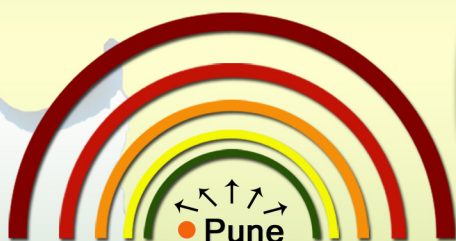# "Metropolitan Advisories for Cities for Sports and Tourism"
(Metropolitan Air Quality and Weather Forecasting Services)

सत्यमेव जयते
पृथ्वी विज्ञान मंत्रालय

Ministry of Earth Sciences
Govt. of India

Puneri-AIR
Pune

SAFAR-Pune

SYSTEM OF AIR QUALITY FORECASTING AND
RESEARCH - PUNE

Indian Institute of Tropical Meteorology, Pune
2012

SAFAR-Pune

System of Air Quality Forecasting And Research - Pune

Authors:

Gufran Beig, D. M. Chate, Neha S. Parkhi, Manasi Karandikar, K. Ali, Trupti Satpute, R. Srinivas, H. K. Trimbake, R.K. Shinde

Indian Institute of Tropical Meteorology, Pune

Earth System Science Organization (ESSO)
Ministry of Earth Sciences, Govt. of India
Indian Institute of Tropical Meteorology, Pune

CONTENTS

सचिव
भारत सरकार
पृथ्वी विज्ञान मंत्रालय
पृथ्वी भवन, लोदी रोड़, नई दिल्ली-110003
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
PRITHVI BHAVAN, LODHI ROAD, NEW DELHI-110003

डॉ. शैलेश नायक
DR. SHAILESH NAYAK

FOREWORD

All life forms are affected by variability in weather, air and water. One of the main reasons for sustenance of life on the Earth is air. Clean air is considered to be a basic necessity of human health and well-being. Human interference in natural processes is increasing in the form of pollutants in recent time. India is also experiencing the deterioration of air quality problem as true for many other countries. For identification of sources and implementing the accurate mitigation strategies, a regular air pollution monitoring and forecasting system is essential, which ultimately will help to minimize the impact on human health and vegetation. ESSO had successfully provided forecast of the air quality of Delhi on the occasion of Commonwealth games for the first time in our country in 2010, and also provided the concept of AQI to translate data into information for the common citizen.

Considering the importance and success of the project, it is planned to extend the air quality and weather forecasting services to at least four major cities. I am pleased to mention that a similar system is being developed for Pune Metropolitan region (PMR) to cover the twin cities of Pune and Pimpri-Chinchwad. This report is a background paper highlighting the first component of this project dealing with Air Quality information services. It briefly addresses the purpose of the system, deliverables, observational network, emission/air quality inventory, air quality forecasting and modelling framework and methodology to spread the knowledge based information to stakeholders. We have also added information on UV-Index which indicates the expected risk of overexposure to the sun's ultraviolet radiation.

I appreciate the effort of our scientific team at ESSO - IITM for their timely efforts to publish this background paper "Puneri-Air (SAFAR-Pune)" and thank all those from the state - government and educational agencies who have extended support by providing the infrastructure to install the monitoring stations and displays.

(Shailesh Nayak)

Tel. : +91-11-24629771, 24629772 ☐ Fax : +91-11-24629777 ☐ E-mail : secretary@moes.gov.in

"The scientific outcome of SAFAR can lead to more targeted, cost-effective clean air actions focused on local populations and agriculture. Either way, local residents would be breathing easier and farmers can think of better crop yields."

प्रो. भूपेंद्र नाथ गोस्वामी FASc., FNA, FNASc., FTWAS

निदेशक

Prof. B.N. Goswami, FASc., FNA, FNASc., FTWAS

Director

Preface

Air is an important link of various processes on earth system. Like other countries, India is also facing the impacts of increased air pollution which is relatively severe in major metropolitan cities of India. A scientific approach through intense research work is required to identify the sources, distribution, dispersion and predictive study of the pollutants, which will be a useful input for implementation of mitigation measures and understand various complex scientific processes. Pune is considered as one of the highly polluted cities of India. Building on the success of SAFAR (**S**ystem of **A**ir quality **F**orecasting **A**nd **R**esearch) system developed and implemented for national capital region Delhi (NCR) during common wealth games in 2010, Pune has been chosen as the second city of India where such a system is being developed which is named as "SAFAR-Pune". This document (Puneri-AIR) provides a brief framework of SAFAR-Pune project implementation plan and a glimpse of field preparation which is planned to be carried out in the coming months. SAFAR-Pune will provide the current and 24-48h advance forecasting information about air quality. A new dimension is added in SAFAR-Pune by introducing the information on Ultraviolet radiation dose called as UV-index. All the components of SAFAR-Pune namely, emission inventory, GIS-modelling, coupled atmospheric chemistry transport model, primary data generation and validation, website development, Air Quality Index (AQI), impacts on health and agriculture are briefly discussed here. As the prediction of air pollutants and identification of the sources are important for deciding the preventive actions and mitigation measures to be taken in the area, the project product is expected to benefit the end user.

(B.N. Goswami)

Director, IITM

SAFAR

MISSION OBJECTIVES

Develop State of the art System of Air Quality Forecasting And Research (SAFAR)

Dedicate SAFAR to nation as an operational service for dissemination of information of air quality products to common public directly related to Human Health and Agriculture

Excel in Frontier of Scientific Research in Atmospheric Chemistry and Improve Forecasting Skill

OUR COLLABORATORS

SAFAR-Pune is a joint venture which could not have taken a speedy path as it is today without the support and co-operation of following collaborating partners:

- **Ministry of Earth Sciences (Govt. of India)**

  1. Indian Institute of Tropical Meteorology (IITM), Pune - Lead Role

     (Nodal Officer & Program Director: Dr. Gufran Beig - beig@tropmet.res.in)

  2. India Meteorological Department (IMD)

  3. National Centre For Medium Range Weather Forecasting (NCMRWF), Noida

- **Collaborating Government Agencies of Pune:**

  1. Pune Municipal Corporation (PMC), Pune

  2. Pimpri-Chinchawad Municipal Corporation (PCMC), Pune

  3. Air force Authority, Western Command, (Ministry of Defence, Govt. of India),Pune

  4. Defence Institute of Advanced Technology (DIAT), (Ministry of Defence, Govt. of India), Pune

- **Collaborating Academic/Professional Institutions of Pune:**

  1. Bharathi Vidyapeeth (BV, Departments of Medical & Environmental Sciences), Pune

  2. Maharashtra Academy of Engineering (MAE), Alandi, Pune

  3. Vasantdada Sugar Institute (VSI, Department of Environmental Sciences), Pune

  4. B. J. Medical College, Pune

  5. University of Pune, Pune

- **Associate Health Service Bodies of Pune:**

  1. Major Hospitals of PMC and PCMC, Pune and Public Health Care Centers

  2. Sasoon Hospital, Ruby Hall Clinic and Apollo Jahangir Hospitals, Pune

  3. Major Private Hospitals in Pune and Pimpri-Chinchwad region

  4. Strategic Health Authorities, Maharashtra State

  5. Health Organizations (NIV, NARI, CRF, Chest Hospital)

- **International Organization**

  1. World Meteorological Organisation (WMO),United Nations, Geneva, Switzerland

     (GURME: University of Iowa, USA)

  2. European Union (EU)

     (GMES-Monitoring Atmospheric Composition & Climate Change-MACC) & BMBF, IEK-8, Juelich

BROADER MISSION GOAL OF MoES

The current report discussed in detail about one of the components "System of Air quality Forecasting and research (SAFAR) of the overall broader mission document of the ministry's 12th 5-year plan scheme "**Metropolitan Advisories for Cities for Sports, Tourism (Metropolitan Air Quality and Weather Services). The broader objective of above scheme is to** develop a System of Air Quality and weather Forecasting and Research in major metropolitan cities of India namely, Delhi, Pune, Mumbai, Chennai, Kolkata, and Ahmedabad, etc. A schematic of above scheme is summarized below:

Metropolitan advisories and services for cities for sports, tourism in India

Air Quality Services → **Basic Science** ← **Weather Services**

Basic Science:
- Generate Emission Scenario
- Understand the inter-linkages
- Short range & long range transport
- Quantify Macroclimate
- Assimilation of Data
- Improve Forecasting capabilities
- Study impact of Air Quality on health & Agriculture

Air Quality Services:

Air Quality Now
- Monitor Air Quality by strategically placed Air Quality Monitoring Stations

Air Quality Forecast
- High resolution Atmospheric Chemistry Transport Forecasting Model
- Forecast AQ 1-2 Days before in terms of public friendly AQI

UV Index
- Radiation meter
- Know the skin damaging UV radiation level & reduce risk of skin diseases

Weather Services:

Weather Now
- Monitor Weather parameters by strategically placed Automatic Weather Station

Weather Forecast
- Forecast Weather parameters 1-2 Days before

Weather Now cast
- Forecast Weather parameters 3-4 hr before
- RADAR/ Satellite data

1.   SAFAR- MOTIVATION

According to the World Health Organization (WHO), metropolitan cities are the most critically affected by the atmospheric pollution. India is one of the fastest economies of the world and rapidly developing. Metropolitan cities of India are expanding with rapid growth in all sectors of life. Due to the rapid development, migration of rural population towards urban metropolitan cities and industrialization, cities like Delhi, Pune, Mumbai, Chennai, Kolkata, and Ahmedabad are on top of the Indian map in terms of pollution. The air pollution problem is directly related to the human health and agriculture. The topography of stated Indian metropolitan cities are unique which has combination of both land and oceanic environment and likely to play an important role in the distribution of atmospheric chemical constituents. The local emissions in the metropolitan cities also affect the ambient level of pollution in the neighboring rural regions due to short range transport of pollution.

One of the most advanced, rapidly expanding city of India is Pune. Pune, cultural capital of Maharashtra, in the western part of the India has experienced rapid urbanization, during the recent years. Also, the process of urbanization is faster in the Pimpri-Chinchwad which is an adjoining twin city. There are around **12** industrial estates and Information Technology Hubs in both Pune and Pimpri-Chinchwad region (hereafter called as Pune Metropolitan Region (PMR)). As centers of multinational trade, commerce and industries, the growth in vehicular traffic is a serious concern. The infrastructural developments, consequent population growth and migration drive the growth of villages into towns, towns into cities and cities into major cities. Consequently, PMR air we breathe contains variety of hazardous emissions which are of great concern for the health of PMR citizens as well as agricultural yield in the region and therefor, a need is felt to address this issue.

2.   SCIENTIFIC COMPETENCE

The very first question which is asked any time, if you attempt an innovative, creative and state of the art project is – "Whether you are capable of doing it in a practical and useful way and what is the scale of VIABILITY". An operational and scientific approach to the aforementioned environmental issues has direct relevance to human health and agriculture yields which has both societal and economic implications. The Indian Institute of Tropical Meteorology (IITM), Pune has capability to undertake such challenging scheme and complete it successfully, in the stipulated period of time. One such venture is demonstrated by IITM under the Ministry of Earth Sciences (MoES)'s project SAFAR in which site-specific air-quality forecast system was put in place in record time with indigenous capability for the National Capital Region (NCR) of Delhi during Common Wealth Games (CWG-2010). Hourly updates to different air-quality and weather products at the Games venues and other strategic locations were provided to organizers of the CWG-2010. With this achievement, Delhi became the first Indian city to have air quality forecasting system SAFAR named as "SAFAR-Delhi". The SAFAR-Delhi has been dedicated to nation on 23rd September 2010. In view of successful implementation of the SAFAR in both operational and research modes, Global Atmospheric Watch (GAW), Global Urban Research Meteorology and Environment (GURME) project of United Nation's "World Meteorological Organization (WMO)" appreciated and recognized it as its pilot project and also recommended to replicate and implementing it in other metropolis for the citizens of India which is likely to set an example for Developing countries.

3.   WHAT IS SAFAR-PUNE?

There is a common wish of IITM that the Acronym "**SAFAR-Pune**" should become a synonymous of air quality forecasting services of Pune city. We can further nickname it as "**SAFAR-Puneri-AIR**" or just "**Puneri-AIR**" as it gets mass appeal. SAFAR-Pune is not only a scientific project but also a mission mode journey with a single point agenda to-
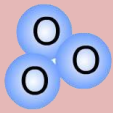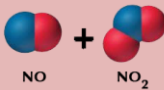
"Enrich the citizens of PMR with location specific current and forecasted air quality information along with Ultraviolet radiation index to help them prepare with advisories to protect their health and skin".

IITM shall develop a system (SAFAR-Pune) to fulfill this mission and dedicate it to nation so that it can become an operational service to serve PMR citizens.

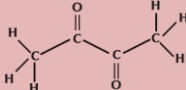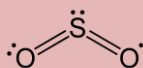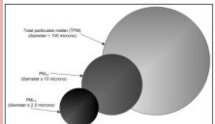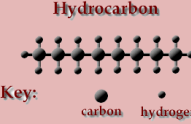SAFAR-Pune will integrate several complex components like air pollution monitoring network (AQMS) at 10 different locations in PMR, 10 integrated automatic weather stations, high resolution emission inventory, activity data and 3-D coupled atmospheric chemistry transport modeling system within PMR (in a area of 40x40 km from its centre) to facilitate current and forecasted information of major criteria air pollutants such as O_3, NO_x, CO, $PM_{2.5}$, PM_{10}, benzene, toluene and Xylene including weather parameters and UV-Index and disseminate the obtained data in terms of meaningful information for a common citizen through various media devices.

4. WHAT IS FORECASTED?

Major air pollutants emitted from various emission sources and which affect our health are-

O_3 (Ozone)	NO_x (Nitric Oxide + Nitrogen dioxide)	CO
BC (Black Carbon)	OC (Organic Carbon) (eg. Diacetyl)	SO_2 (Sulphur dioxide)
PM10 PM2.5 (Particulate Matter)	HCs (Hydrocarbons)	Hg (eg. Methyl Mercury)

There are 5 key criteria pollutants which are most hazardous to our health and crop yields, will be forecasted namely PM2.5, PM10, O_3, CO and NOx. Although the information about other pollutants namely Benzene, Toluene, Xylene, CO_2, BC and Hg will also be collected for research and development purposes.

5. SOURCES OF POLLUTANTS

There are number of sources both anthropogenic as well as natural but what is concern to all of us is anthropogenic sources which are rapidly increasing. In general there are 4 broad sectors of anthropogenic emission sources as follows:

1)Industrial Sector

2)Transport Sector (Fossil Fuel Emissions)

3)Domestic or Residential Sector (Bio-fuel Emissions)

4)Power Sector

In Pune, industries and IT establishments are mostly located in Talegaon, Chakan, Hinjavadi, Talavade, Chinchwad, Pimpri, Bhosari, Kharadi, Hadapsar, Gultekdi and Parvati. Many of the small scale industries in and around PMR are engaged in production of products (agricultural implement, pump-set, engine, paper, medicine, rubber, plastic material, soap, nylon, electrical and electronic appliances, wooden furniture, etc). In the rapidly growing cities like PMR, anticipating increase in population further increases –Infrastructure, Automobiles and Industries. The **transport sector** related emission further depends on the following factors:

a) Transport Sector Subsets:

- Fuel Quality
- Vehicle Maintenance
- Traffic Congestion
- Narrow Roads
- Paved and Unpaved Roads
- Old Automotive Technologies

There are some less talked about sources which also play a dominating role in deteriorating air quality of PMR. They are:

Suspended Dust from Roads: **Construction Activities:**

b) Bio-fuel emissions & Bio-mass Burning:

c) Other Habits /Sources

Population also gives rise to domestic **sewage** pollution. The changing **lifestyle** and growing requirements of the increasing standard of living tend to increase consumption of goods, thereby leading to increase in the generation of wastes. The changing population, **food habits**, standard of living, **land** use pattern and large scale **commercial** and **industrial** activities. These all sources generates huge amount of solid wastes and significantly affects **biodiversity** of these twin cities.

6.   HEALTH IMPACT OF POLLUTION

Health effects caused by pollution are reflected through increasing incidences of several immediate symptoms as mentioned below and hence push the alarm button. Knowing these sources of deteriorating air-quality is important to health professionals, policy makers and scientists who are always looking for effective solutions and preventive actions to maintain clean PMR air.

Health symptoms of pollutants:

Cough/ sneezing   Headache   Nausea

Eyes Irritation   Bronchitis   Respiratory Diseases

In addition to the above, continuous exposure to excessive air pollution may lead to several types of terminal diseases like Asthma, cardiac arrest, tuberculosis, pulmonary diseases.

7.   WHY PUNE NEEDS SAFAR-PUNE?

For a city like PMR, assessment of environmental pollutants exposure and its impact on human health, vegetations, water quality and ecosystem became a necessity so as to spread awareness among masses. It is felt necessary that knowing the quality of air we breathe and its knowledge in advance would go in a long way for the citizens living in PMR to prepare ourselves and take preventive measures. The atmosphere of awareness and sensitizing citizens on the subject would likely to pave the way for mitigation step to an individual and also to formulate the strategies for policy makers. This will eventually lead to betterments of people living in PMR. In view of the above, it has been decided by the Ministry of Earth Sciences (MoES) to develop a science plan called "*Metropolitan Advisories for Cities for Sports and Tourism"* under which an ambitious project "*Metropolitan Air Quality and Weather Forecasting Services*" has been conceived and planned to be jointly executed by 3 constituents of the ministry namely, IITM, Pune, NCMRWF, Noida and IMD, New Delhi with a leading role by IITM, Pune. Under this plan, an ambitious project called "**System of Air Quality Forecasting and Research**" **(SAFAR)** has been designed by Indian Institute of Tropical Meteorology, Pune (IITM) which deals with air Quality Information and the present document is dedicated to this last theme only.

8.   SAFAR PRODUCTS AND COMMUNICATION TO PUBLIC

8.1 Air Quality (AQ) Information
(Human Health Advisories)

AQ-Now (Current) AND AQ-Tomorrow:

- **AQ by Colours**
  (Green, Yellow, Orange, Red and Maroon)
- **AQ by Text**
  (Good, Moderate, Poor, Very poor, Very Unhealthy)
- **AQ by Number**
  (Air Quality Index; 1-500),
- **AQ by Pollution Maps**
  (Contours hot spots, extreme and low events)
- **AQ Caution & Advisories**
  (Based on indigenised WHO guidelines)

AQI Display Symbols

8.2 Radiation Information (UV-Index)
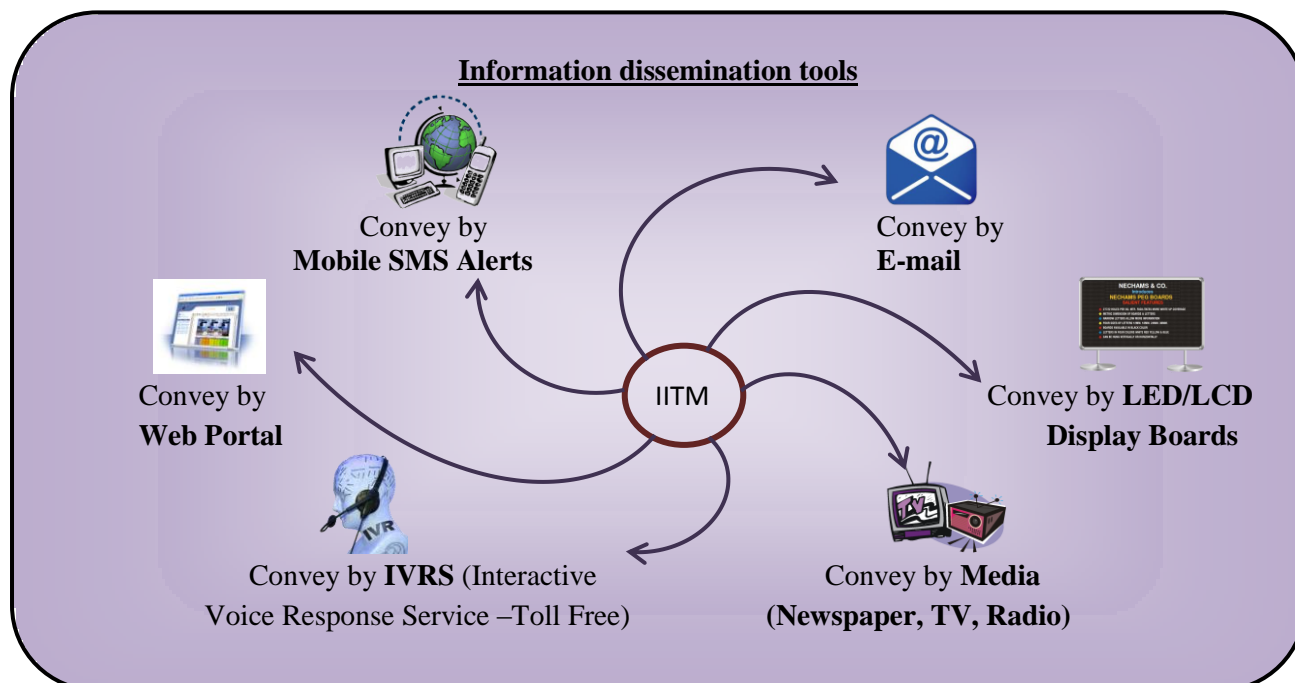*(Human Skin related advisories)*

The UV Index, on a scale of 1 to 10 provides information about the expected risk of overexposure to the sun. Overexposure to ultraviolet radiation (UV-A, UV-B) can cause sunburn, skin cancer, cataracts, etc.

- **UV Index by Colours**
  (Green, Yellow, Orange and Maroon)
- **UV Index by Text**
  (No Risk, Low risk, Medium Risk and High Risk)
- **UV Index by Number**
  (1-10 corresponds 0-4, 5, 6-9, 10+)
- **UV Caution & Advisories**
  (Based on indigenised WHO guidelines)
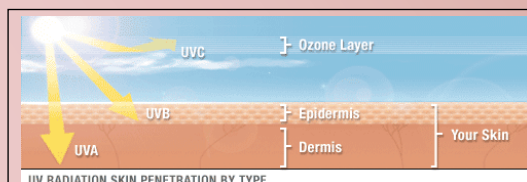
8.3   Sources of Dissemination of Information to End User

Once product is produced, we should have to have a mechanism to convey the information to stake holders, disaster management authorities and directly to citizens. This is required so that public awareness is created and preventive measures can be taken up by them. In a long run, it will eventually lead to firm up the mitigation strategies to protect Human health. This will be accomplished by the following via media:

Information dissemination tools

Convey by **Mobile SMS Alerts**

Convey by **E-mail**

Convey by **Web Portal**

IITM

Convey by **LED/LCD Display Boards**

Convey by **IVRS** (Interactive Voice Response Service –Toll Free)

Convey by **Media** (Newspaper, TV, Radio)

8.4   Benefit to End User

Planning of agricultural crop yields benefit		Basis for mitigation strategies to protect Human health	
Awareness on Impact of Air Quality and Weather		Improvement in **weather Forecasting Skill** via chemistry feedback	

8.5   Basic Science and Research Goals

- Explore **Chemical-Weather (Chemistry of the Atmosphere or Weather)**
- Interpret short term and long term variability in chemical and physical processes in Earth Climate
- Relative contribution of **local emission versus transport** from neighbouring states
- Improvement in **weather Forecasting Skill** via atmospheric chemistry feedbacks
- Generate **Emission** scenarios & **Assimilation** of air quality data.

9.   AIR QUALITY AND WEATHER MONITORING NETWORK

IITM, Pune is setting up integrated Air Quality Monitoring Systems (AQMS) along with the Automatic Weather Stations (AWS) at 10 (Ten) different strategic locations within the Pune, Pimpri-Chinchwad and neighbouring regions (35km x 35km from the centre of Pune city) as shown in Figure-3. IITM is grateful to all their partners who have extended their full cooperation and support by providing the infrastructure and other facilities

Measurements of CO, NOx, HCs (Benzene, Toluene and Xylene), Hg, PM_{10}, $PM_{2.5}$, BC and OC, will be made at about 3m above ground, through the AQMS stations consisting of online pollutant analyzers. Theses analyzers will be operated round the clock and the data will be recorded and stored at every five minutes interval for quality checks and scientific analysis. The data will be subsequently averaged to one hour interval. Calibrations of the online analyzers will be performed at appropriate time interval using inbuilt calibrators for some pollutants or with external calibration cylinders with multipoint calibration techniques for other elements. Besides these data, meteorological parameters (Temperature, Rainfall, Humidity, Winds speed, wind direction) and Ultraviolet radiation flux in terms of erythemal UV dose will also be monitored using AWS and UV-E radiometer.

| Code	Location	Institute/Organization name
M1	Pashan	Indian Institute of Tropical Meteorology
M2	Shivajinagar	India Meteorological Department
M3	Pune Airport Lohegaon	Airforce base, Pune
M4	Alandi	MAEER's Maharashtra Academy of Engineering
M5	Katraj	Bharati Vidyapeeth
M6	Hadapsar	Lohiya Udyan, PMC
M7	Bhosari	PCMC
M8	Nigdi	PCMC
M9	Manjri	Vasantdada Sugar Institute
M10	Girinagar	Defense Institute of Advance Technology
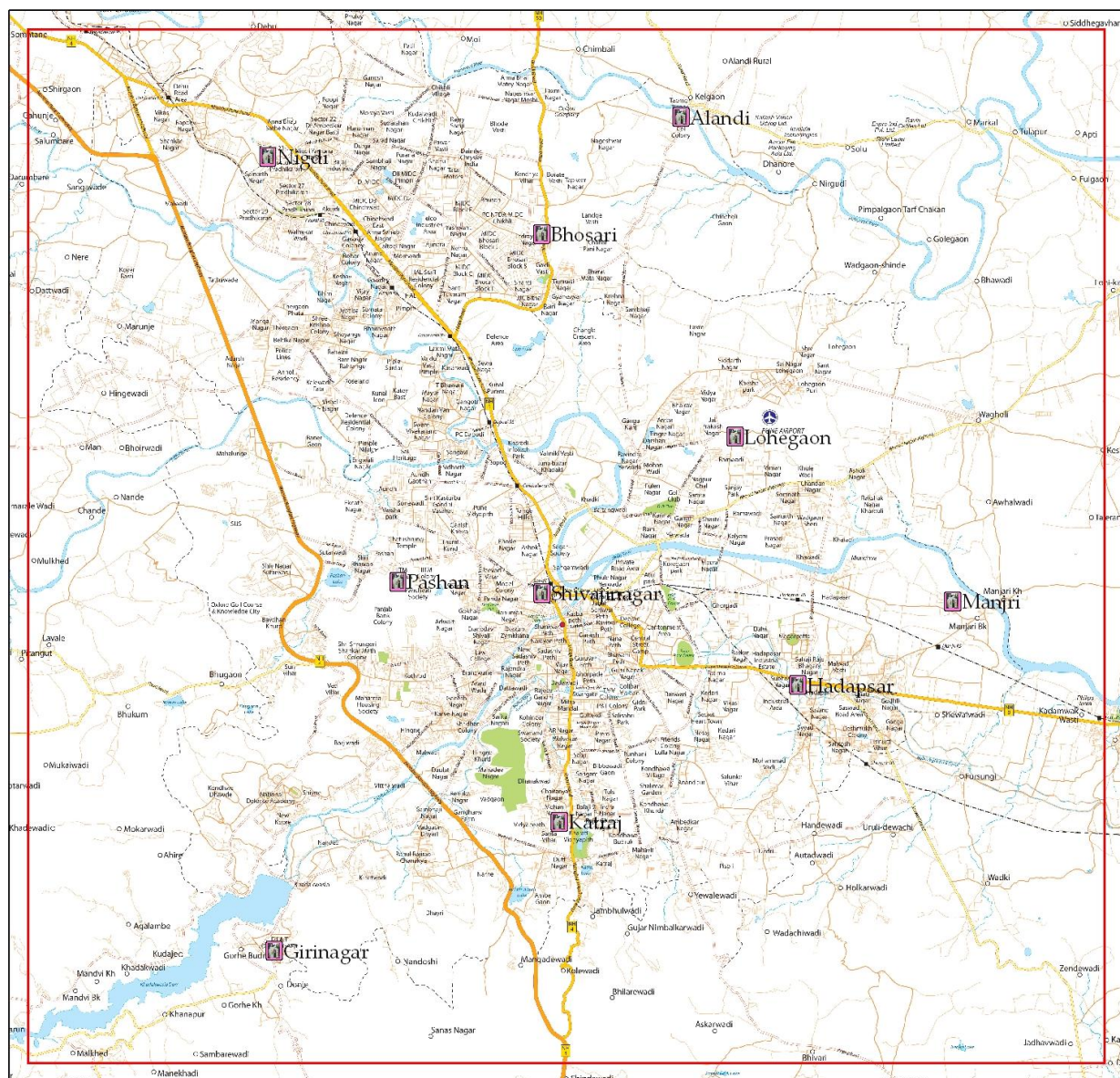
Fig.-1. Location of 10 Monitoring stations in Pune Metropolitan Region.

10. EMISSION INVENTORY DEVELOPMENT

Emission Inventory is a comprehensive listing by sources of air pollutant emissions and amount of air pollutants released into air as a result of a specific process in a particular geographic region during a specific time period. This is one of the most critical factors required for 3-D atmospheric chemistry transport models along with meteorological input to forecasting the air quality for mitigation. Quality of forecasting depends on accuracy and reliability of emission estimation. Emission inventories could also be used for air quality management and formulating environmental policy.

Development of emission inventory is a complex process due to numerous, diverse and widely dispersed emission sources in city like Pune and its adjacent region and requires huge amount of high resolution activity data, emission factors along with knowledge of fundamental scientific processes. Scientists of MoES are involved in this area of research for more than a decade at IITM, Pune and published first ever inventory of several pollutants for our country India in international journals. For the development of emission inventory of PMR, a bottom up approach has been used for which a GIS (Geographical Information System) based statistical model has been developed by our scientists at IITM to prepare high resolution gridded emission inventory. The emissions have been estimated for the individual sources and for that purpose, an extensive scientific field campaign has been carried out in PMR region during the past several months by involving more than 100 students and scientists from different colleges and university by which a noble cause to inculcate the feeling of scientific temperaments in young mind is also achieved. The main focus of the

campaign was to generate missing primary data, validate some uncertain secondary data and to collect the available secondary data. Our Scientists are in the process of developing the high resolution (1.67 km x 1.67 km) emission inventory of all major air pollutants for PMR to facilitate accurate air quality forecasting. Emission inventories have been developed for 8 air pollutants namely, *Oxides of Nitrogen (NO_X); Carbon Monoxide (CO); Black Carbon (BC); Organic Carbon (OC); Particulate Matter <2.5 micron ($PM_{2.5}$); Particulate Matter <10 micron (PM_{10}); Sulfur Dioxide (SO_2) and Volatile Organic Compounds (VOCs).*

11.   AIR QUALITY FORECASTING

The air quality forecasting is a highly specialized area. It requires huge computational power on regular basis (see Figure-2). This air quality forecasting model is known as "Atmospheric chemistry transport model". To forecast the air quality of various pollutants along with weather parameters, IITM uses four nested domain starting from near global to the local city level covering PMR and neighboring region. The inner PMR domain will have a resolution of 1.67 km x 1.67 km which means that we can get the information of air quality at each 1.67 km grid interval within PMR. All these 4 domains will run interactively and feedback of meteorology to chemistry and vice-versa will be accounted. This model requires several key inputs for accurate forecasting. Major among them are- emission inventory of pollutants from various sources, weather parameter, topographical data, land use-land cover data, initial and lateral boundary conditions, etc. The initial and lateral boundary conditions for the outermost domain in meteorological model will be taken either from NCEP reanalysis or from internally generated CFS of NCMRWF, Noida whereas for the chemical forecast model, it will be taken from MACC (Monitoring Atmospheric Composition and Climate), a project of European union under MoU between IITM and EU- project partners. An intensive filed campaign by involving more than 100 college students and researchers has been conducted for a few months at PMR to collect the primary and secondary activity data to generate the emission inventory of pollutants which has constituted a key input to forecasting model.

Fig.-2. HPC (Prithvi) Supercomputer of IITM for SAFAR model simulation Forecasting.

12.   DATA COLLECTION, PROCESSING AND DISSEMINATION

A schematic of data management is illustrated in Figure-3,4. Near real time online raw data from 10 Stations will be transferred to *AQMS Server* in control room at IITM, Pashan, Pune through GPRS network. The raw data will then be converted in the public friendly format like AQI or UV-Index, etc. Thereafter it will finally be achieved into *FTP Master Control Server* with wired connectivity where data will also be quality assured and quality controlled by the expert scientific team instantly. This data set will then be available for dissemination to generate information products. The air quality forecasting data for the next day will be available 30 hours in advance from HPC facility of IITM to FTP master control server. The FTP master control server will have responsibility to channel the data to *Display Server* from where it will be converted to user friendly products as stated in section-8 and then required product information will be transmitted to various LED display boards around PMR via 3G communication network. FTP server will also cater the data to WEB server of SAFAR-Pune and to various service providers like IVRS and media.
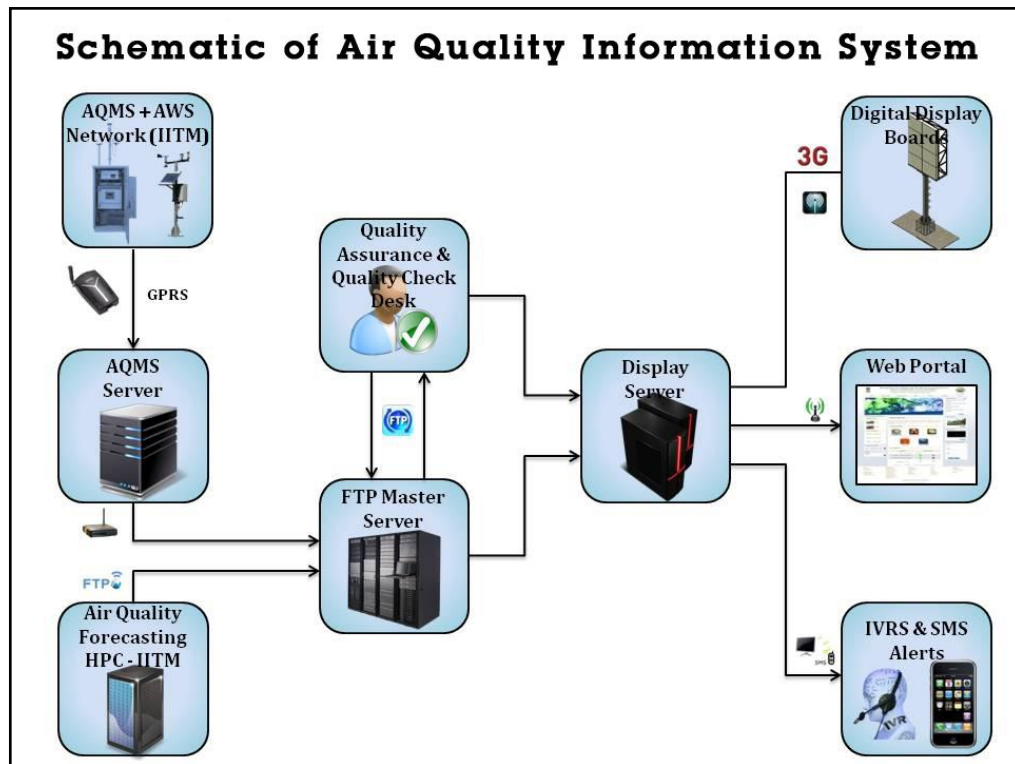
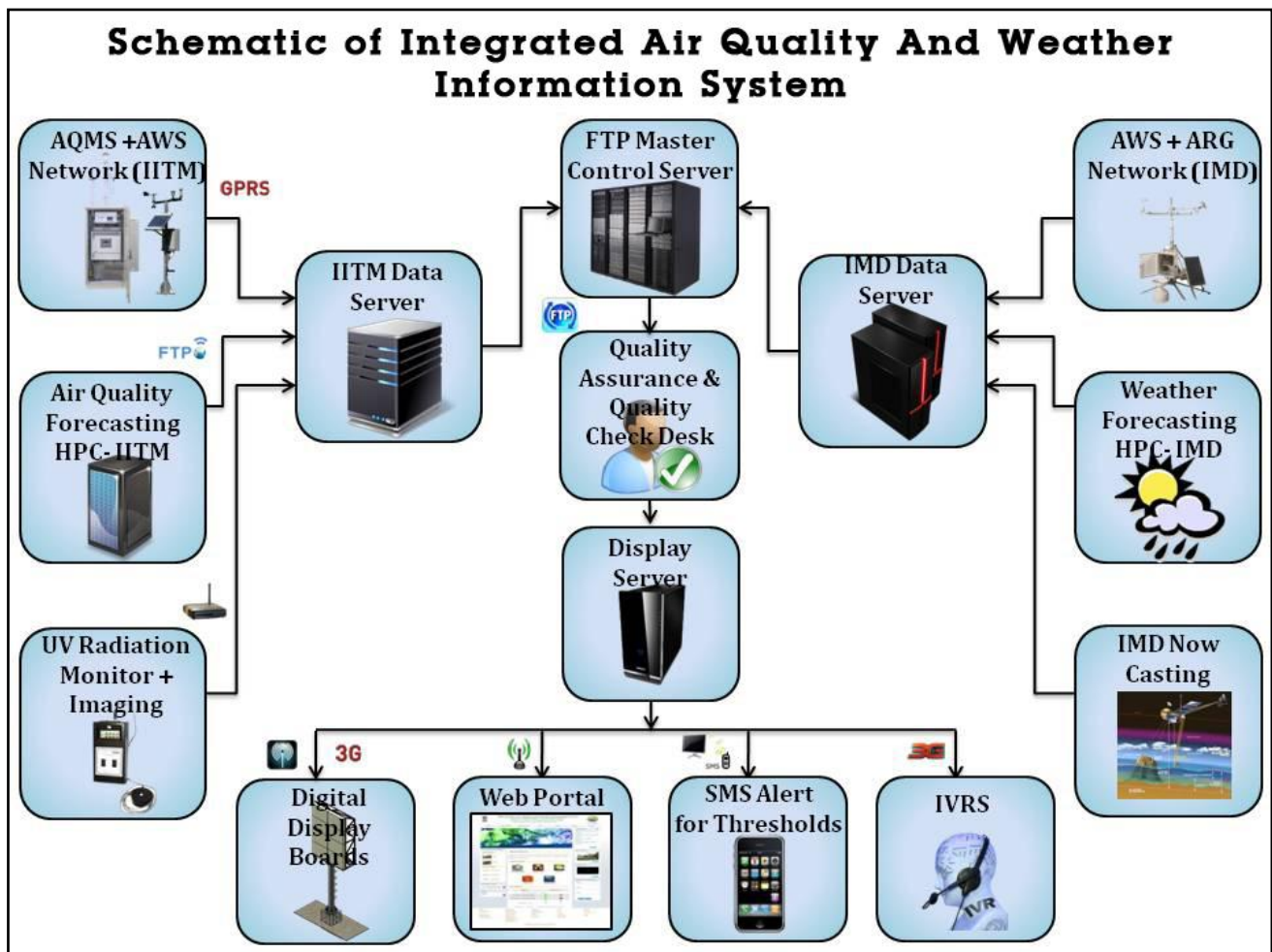Fig.-3. Flow chart of Air Quality data collection and Processing at IITM

Fig.-4. Flow chart of Air Quality and Weather Data collection and Dissemination.

13.   COMMUNICATION TO COMMON PUBLIC

The SAFAR Program will provide Pune with timely and accurate air quality information so that citizens can make informed decisions regarding their health. The public can access the AQI and air quality forecasts via web portal, or by calling the SAFAR air quality information Integrated Voice Response service (IVRS) toll-free (English, Hindi and regional language recording). Those interested in information on e-mail, can contact-*safar@tropmet.res.in*. The Air Quality Index values for current time and 24 advance forecast for downtown city area and residential suburban area will be reported, in near real-time, on the SAFAR web site **http://safra.tropmet.res.in/pune** updated hourly, 24-hours, seven days a week. Scientific air-quality information of SAFAR-Pune in near real time will also be available on public Display Systems. The information will be updated at each hour to notice the variability and to know most current air quality conditions.

Quality Assurance and Quality Controls: Recent provisions will be made to make available the detailed air quality information and technical improvements to the web site such as geographical display of data, station information result for better protection for the people of Pune. The public may subscribe to the Alert Network to receive direct emails of extreme condition alerts. **Overall,** we are committed to the scientific principles (i.e., accessible, responsive, reliable, caring, accountable; consistent, predictable, transparent, continuous improvement) and common service standards (i.e., response times to general phone calls, mail, email, public displays).

What is Air Quality Index (AQI) ?:

The AQI has been developed to provide advice on expected levels of air pollution. In addition, information on the short-term effects on health that might be expected to occur at the different bands of the index (Good, Moderate, Poor, and Very Poor, Critical) is provided. It is expected that the vulnerable people, children and asthmatic people may experience health effects even on Low air pollution days (long-term). This advice applies to anyone experiencing symptoms. The purpose of the AQI is to help you understand what local air quality means to your health. The value of AQI corresponds to concentration of the specific pollutant present in the air at the time of measurement. Different AQI values are generated for various pollutants. To make it easier to understand, the AQI is divided into color bands as shown in Figure-5.

Air pollution has a range of effects on health. It will be interesting to know the air pollution levels at which people need to make major changes to their living habits to avoid exposure. However, nobody needs to fear for going outdoors to perform their routine activities. Severity of the presence of air pollutant depends on its concentration in the air. AQI value represents the concentration of pollutant in the air. AQI level can be interpreted for health impact as:
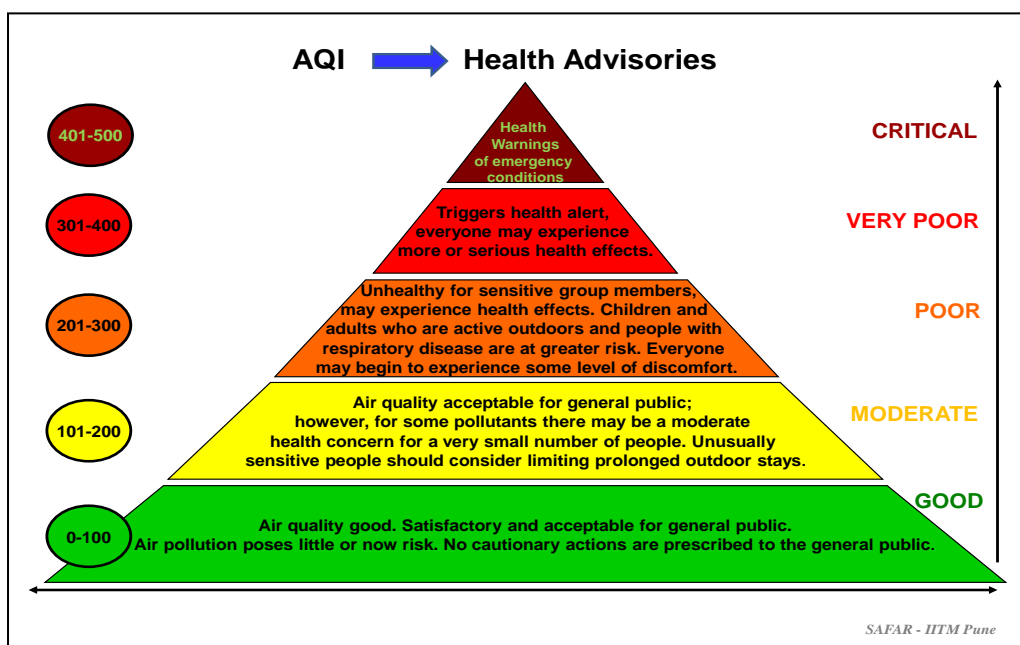

Fig.-5. Different categories of AQI shown in different colours and associated impacts.

1) **Good** : AQI (0-100) : Health effect : Air quality is good/acceptable, there is very little or no risk for general public. Precautionary measures are not required.
2) **Moderate** : AQI(101-200) : Health effect : Air quality is acceptable for general public. It will be better if sensitive people like patients suffering from respiratory and heart diseases avoid prolonged outdoor activities.
3) **Poor** : AQI(201-300) : Health effect : General public may experience some discomfort/health effects during regular activities. It is unhealthy for a group of sensitive people, children and older people may get affected by outdoor activities by environmental exposure.
4) **Very Poor** : AQI (301-400) : Health effect : Unhealthy for general public, everyone will experience more or less health effects. There is a need to take precautionary measures.
5) **Critical** : AQI (401 -500) : It is an emergency alarm for everyone. Immediate precautionary measures are required.

| GOOD | MODERATE | POOR | VERY POOR | CRITICAL |
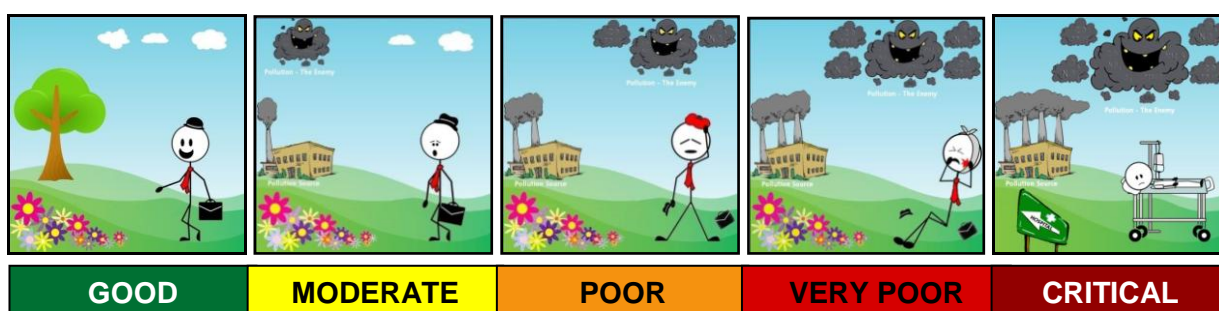
14.   UV RADIATION ALERTS (SKIN RELATED RISKS):

UV-Index for India defined by MoES (IITM)

UV Index Number	Exposure Level
0-4 (Green)	No Risk
5 (Yellow)	Low Risk
6-9 (Orange)	Medium Risk
10 & Above (Maroon)	High Risk

Definition

The UV Index is a measure of the amount of skin damaging UV radiation expected to reach the earth's surface at the time when the sun is highest in the sky (around midday).

The UV Index for India is developed and proposed by the Ministry of Earth Sciences after extensive research work based on the analysis of the time series of long term stratospheric ozone data and carrying forward from the guidelines of World Health Organization. The UV Index provides the expected risk of overexposure to the sun. The Index give UV intensity levels on a scale of 1 to 10+, where 1 indicates a low risk of overexposure and 10+ signifies an extreme risk.

We all wish to have sunlight. In summer the sun bites us whereas in winter sunlight can be enjoyable. However, too much exposure to sun could be dangerous. Overexposure to the sun's ultraviolet (UV) radiation can cause immediate effects, such as sunburn, and long-term problems, such as skin cancer and cataracts even if you have dark skin color. The amount of UV radiation reaching the surface is primarily related to the elevation of the sun in the sky, the amount of ozone in the stratosphere, and the amounts of cloud cover. However, thick cloud can greatly reduce ultraviolet radiation levels and, surprisingly, certain types of thin cloud can magnify the ultraviolet radiation strength.

Exposure Level Attributes:

UN-Index and Preventive Steps

By adopting a few simple precautions daily, you can greatly reduce your risk of sun-related illnesses. This problem is most severe during summer in India. These steps are as follows:

- Do Not Burn
- Avoid Sun Tanning and Tanning Beds
- Generously Apply Sunscreen with an SPF of at least 15
- Wear Protective Clothing, Including a cap, Sunglasses, and Full-Length Clothing
- Seek Shade as much as you can afford in your daily routine.
- Use Extra Caution Near Water, Snow and Sand
- Watch for the UV Index
- Get Vitamin D Safely

15. DYNAMIC WEBSITE SERVICE

A dynamic professional website is being developed which will be hosted and maintained by IITM. AQI and weather products as discussed in section 8 will be uploaded with graphics and animation on web portal. The URL of Web portal is: http://safar.tropmet.res.in/pune.

Fig.-6. Website for SAFAR-India with special reference to SAFAR-Pune is in making.

16.   LED-DISPLAY BOARDS FOR INFORMATION

IITM, Pune will setup at least 12 LED display boards of size 10' x 6' dimension erected at 12 feet high pole in and around PMR for maximum public viewing at strategic locations of highest areal visibility (~200m). The locations of LED displays are provided in Figure-8.

These display boards will be covered with ALCO panel and will have intensity controller. All the display boards will be interfaced with the control room at IITM and get the data through 3G networking for delivery and updating of the air-quality and weather data products. 3G modems will be installed in all display boards as well as in the IITM display server.

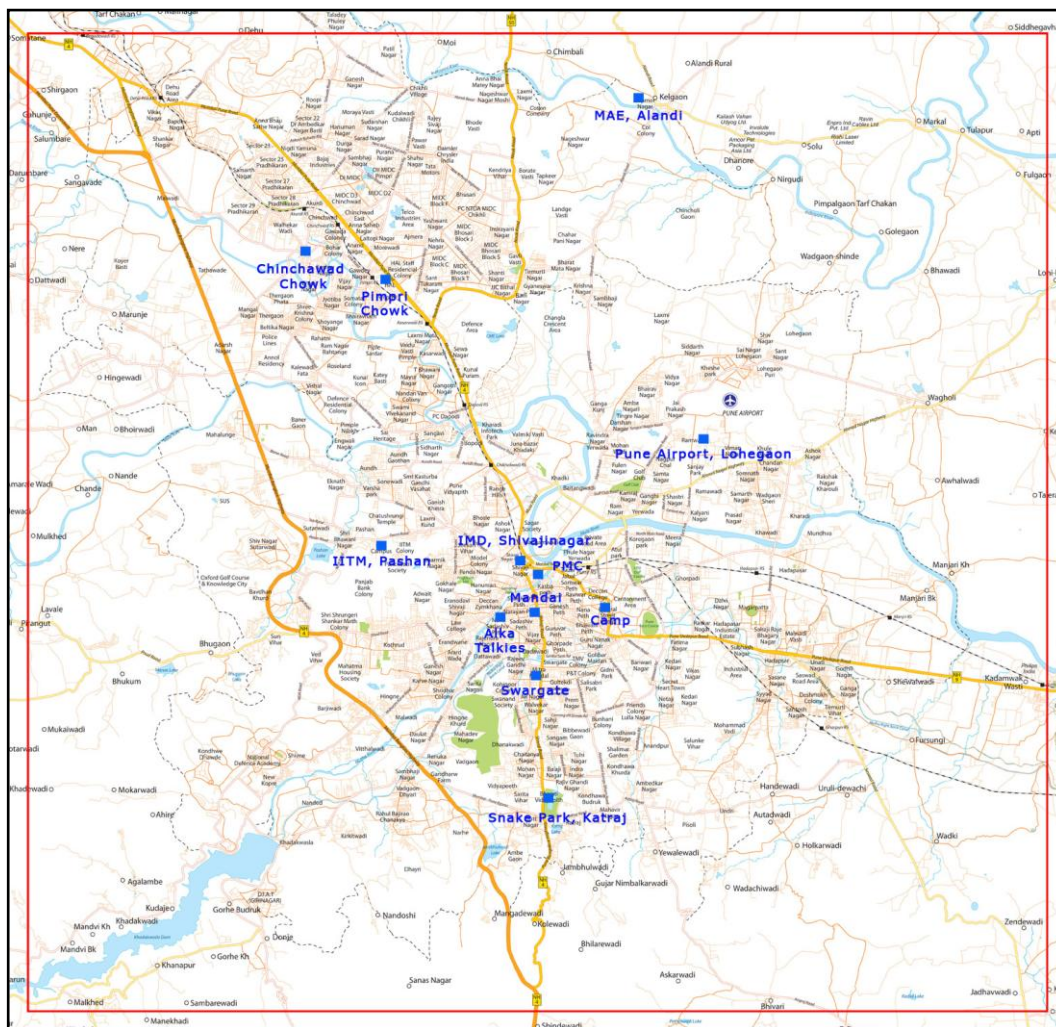Fig.-7. Sample of LED, LCD Display for disseminating Air Quality information

Fig.-8. Location of 12 Digital Displays in Pune Metropolitan Region.

Code	Location	Institute/Organization name
D1	Pashan	Indian Institute of Tropical Meteorology
D2	Shivajinagar	India Meteorological Department
D3	Pune Airport, Lohegaon	Airforce base, Pune
D4	Alandi	MAEER's Maharashtra Academy of Engineering
D5	Katraj Snake Park	PMC
D6	Camp	PMC
D7	Pimpari Chowk	PCMC
D8	Chafekar Chowk	PCMC
D9	PMC, main Office	PMC
D10	Swargate	PMC
D11	Alka Talkies Chowk	PMC
D12	Mandai	PMC

17. SAFAR-INTERACTIVE VOICE RESPONSE SERVICE (IVRS)

IVRS - Interactive Voice Response Service - is a technology that automates interactions with telephone callers. IVRS solutions will enable users to retrieve information on SAFAR from any telephone. We intend to develop an Interactive voice response System, or IVRS, which is a computerized phone system that enables a person, typically a telephone caller, to make a selection from a voice menu to know about the current and forecasted air quality and weather information on a particular location within a city. The selection is made using touch-phone keypad entries or voice responses. The phone system plays pre-recorded voice prompts and the person typically presses a number on a telephone keypad to select the option associated with the voice prompt as per the information required which will be updated hourly based on the SAFAR products. The public can access the AQI and air quality forecasts via Integrated Voice Response service (IVRS) by calling toll-free (English, Hindi and regional language recording) phone number to get information in the city and city outskirt areas for Pune and Pimpri-Chinchwad regions.

18. HOW TO RESPOND TO SAFAR ALERT SERVICE

Once the existing air quality and prediction of tomorrows AQI is known in advance then the necessary precautionary measures can be taken at the earliest by the citizens of PMR as advised. *Know & Respond to SAFAR-Pune* is free service to subscribers in PMR that sends registered users an alert message to their mobile phones as a text message, voice-mail or e-mail, if air quality in their area is forecasted to be Very Poor or Very Unhealthy. The alert service is provided for anyone wishing to know about the quality of the air they breathe. It will be of particularly beneficial for doctors in various hospitals situated in PMR in order to issue health advisory to people with medical conditions that may be affected by pollution, such as asthma, bronchitis and emphysema. It may also be beneficial for people whose breathing gets worse when air pollution increases. This early warning service allows you to make informed decisions and to take action if necessary to minimize the effects of pollution episodes in ones day to day life styles.

Due to the restricted content of SMS, an abbreviated alert (as in picture) will be sent to SMS subscribers with further details available on the website. In order to receive alerts in full, please select Voicemail or email options when subscribing.

18.1   Prepare for Alert Service

When levels of air pollution increase it would be sensible for those who have noticed that they are affected to limit their exposure to air pollutants. This does not mean staying indoors, but reducing levels of exercise outdoors would be reasonable. Preventive Measures on Alerts:

- **Older people /those with heart & lung conditions** might avoid exertion on High pollution days.
- **Adults and children with asthma** should check that they are taking their medication as advised by their health practitioner and may notice that they need to increase their use of inhaled reliever medication.
- **Adults with heart and circulatory conditions** should **not** modify their treatment schedules on the basis of advice provided by the air quality index: such modification should only be made on a health practitioner's advice.
- **Some athletes**, even if they are not asthmatic, may notice that they find their performance less good than expected when levels of a certain air pollutant (ground level ozone) are High, and they may notice that they find deep breathing causes some discomfort in the chest: This might be expected in summer on days when ground level ozone levels are raised. This does not mean that they are in danger but it would be sensible for them to limit their activities on such days.

18.2   Families and Health Care Professionals

When individuals would have reliable information, they can act on it. The information would have been accessed with this tool can benefit everyone, particularly asthmatics, children, and other sensitive populations who depend on accurate pollutant information to make decisions, on a daily and hourly basis, about their activity levels. For example, a mother of an asthmatic child can check the current AQI to decide whether her child should go out to play outdoor games. Health care providers could urge their sensitive patients and the public to consider the AQI in planning their outdoor activities. Print and Electronic Media can show the air-quality and weather products on their resources.

18.3   Emergency Planning /Response

Air quality can change rapidly during fireworks displays for various celebrations (Deepavali, Ganesh festivals, Vijaya Dashmi, etc.). Access to real-time air quality information can be crucial for planning and responding to these situations. This tool presents the data in a visual manner on a Public Displays and can be used by various departments or response teams (e.g. disaster management authorities).
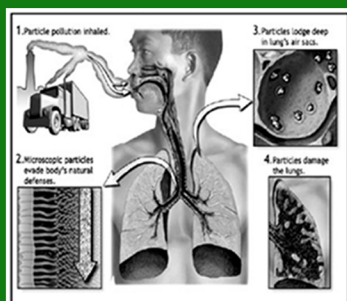
19.   SUMMARY OF SAFAR MISSION

The complete " Metropolitan Air Quality and Weather Forecasting Services" scheme which includes SAFAR (discussed above) is depicted in the below mentioned schematic for an easy understanding at a glance. It provides a nice conceptual framework and deliverables in few words.
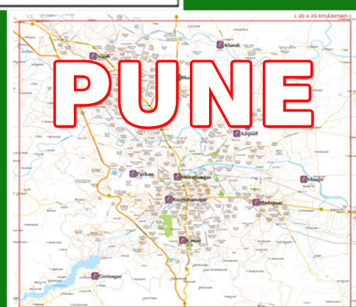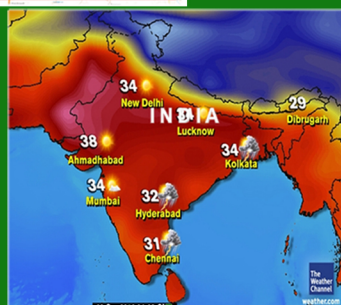

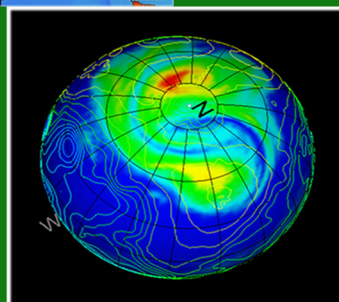========================

big ideas
FOR A SMALL PLANET™
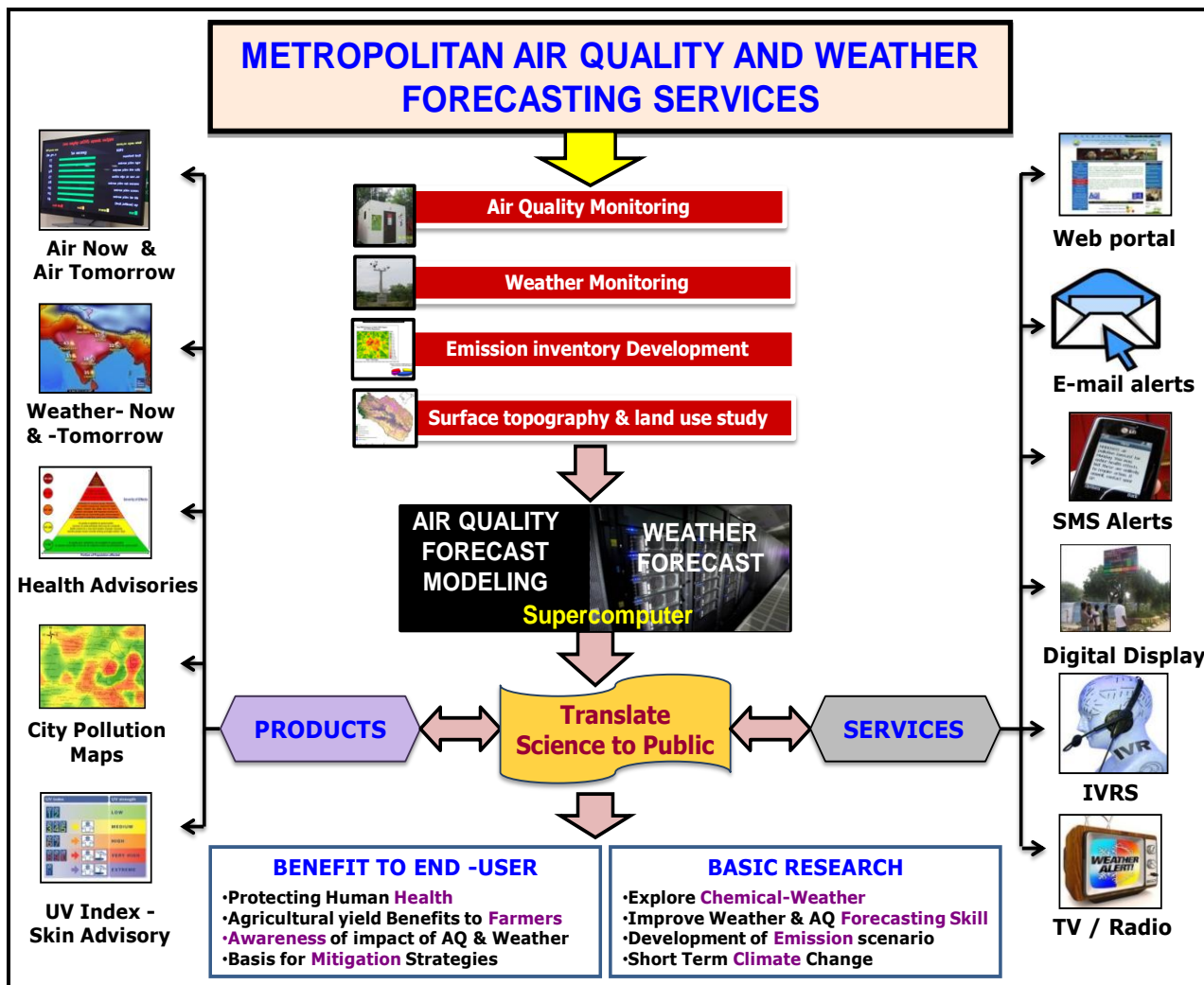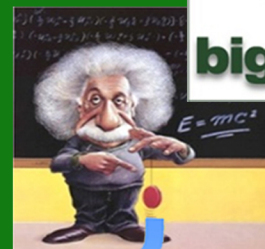
Impacts

City Forecast
Air Quality Model

PUNE

Regional
AQ Model

Global
CT-GCM

Making a Mark in Air Quality Forecasting

Ministry of Earth Sciences, Govt. of India

Indian Institute of Tropical Meteorology, Pune

(An Autonomous Institute of the Ministry of Earth Sciences, Government of India)

Dr. Homi Bhabha Road, Pashan, Pune – 411 008, India

Phone: +91-20-2590-4200   website: http://safar.tropmet.res.in   Email: safar@tropmet.res.in