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DISASTER MANAGEMENT

Countrywide Fire Hazard and Risk Analysis for Revamping the Fire and Emergency Services in India

SUMMARY

Growth of fire and emergency services in India is on ad-hoc basis without much scientific analysis of existing risk to different parts of the country, which needs different kind and types of equipment depending upon risk in the coverage area of Fire Station and its geographical location. As per analysis by Standing Fire and Advisory Council norms, the overall deficiency in the country was estimated more than 80 percent in Fire Fighting & Rescue Vehicles and more than 96 percent in Fire Stations & Fire Personnel, respectively, which is quite alarming. To address these and other related challenges, RMSI carried out unique kind of Geographic Information System (GIS) based comprehensive study for the entire civil Fire and Emergency Services to develop a roadmap for revamping the Fire and Emergency Services in the country.

Introduction

Fire service is one of the most important emergency response services in the country, which comes under the 12th schedule of the constitution dealing with Municipal functions. In India, at present, the fire prevention and firefighting services are organized by the concerned States and Union Territories (UTs), and Urban Local Bodies (ULBs). Directorate of National Disaster Response Force and Civil Defence (NDRF & CD, Fire Cell), Ministry of Home Affairs (MHA) renders technical advice to the States, UTs, and central ministries on fire protection, prevention, and legislation. Fire services in Maharashtra, Haryana, Gujarat, Chhattisgarh, Madhya Pradesh (excluding Indore), and Punjab fall under the respective municipal corporations of these states. In the remaining states, they fall under the respective Home Departments.

In India, there has been only an ad-hoc growth of fire-services without much scientific analysis of the existing risk in different parts of the country. The authorities have been neglecting the fact that different kind and types of equipment are required, depending upon risk category and coverage area of a Fire Station, its geographical location such as hilly-areas, coastal-areas, desert areas (water-deficient areas), and residential (high-rise, medium, and low rise-buildings), industrial, or commercial area or a combination of these. Moreover, lack of knowledge management for future planning, institutional capacity and funds are also seen as major challenges in addressing improvements in fire and emergency services in the country[2]. As per analysis by Standing Fire and Advisory Council (SFAC) norms, the overall deficiency in the country in terms of number of Fire Stations is 97.54%, in terms of firefighting and rescue vehicles is 80.04% and in terms of fire personnel is 96.28%, respectively, which is quite alarming[1].

In consideration of this and the increasing fire risks from various hazards, the Fire Cell of NDRF & CD felt the need for a comprehensive GIS based study to identify existing gaps in the fire services of the country in terms of availability and requirement of fire stations, capacity-building both in terms of trained man-power and fire-fighting, rescue, and other specialized equipment. This comprehensive study was aimed to prepare a Perspective Plan for next 10 years for Revamping the Fire and Emergency Services in the country.

RMSI conducted a detailed Global Positioning System (GPS) based field-survey of India's entire civil fire-infrastructure and conducted detailed GIS based Fire Hazard and Risk Analysis to develop a Web-GIS based "Fire Decision Support System (FDSS)"[2]. This tool is helping Fire Cell of NDRF & CD as well as Fire and Emergency Directorates' of all the States and UTs of the country in revamping fire and emergency services.

Usage

Approach for Development of Comprehensive Roadmap

The primary goal of this study was to prepare a capital investment and institutional strengthening plan for accelerated development of fire and emergency services in the country. The key objectives of this study were:

1. Identify gaps in the existing fire services through conducting field investigations and interviews.
2. Assess the gaps and needs for future planning, up-gradation/ modernization of the fire service infrastructure in the country in a quantified approach.
3. Develop detailed 'Investment and Financial Plan' including Capital and O&M Investment plan for the next 10 years and the investment priorities.
4. Institutional Assessment and Capacity Building Plan.

In order to achieve these objectives, the following tasks were undertaken:

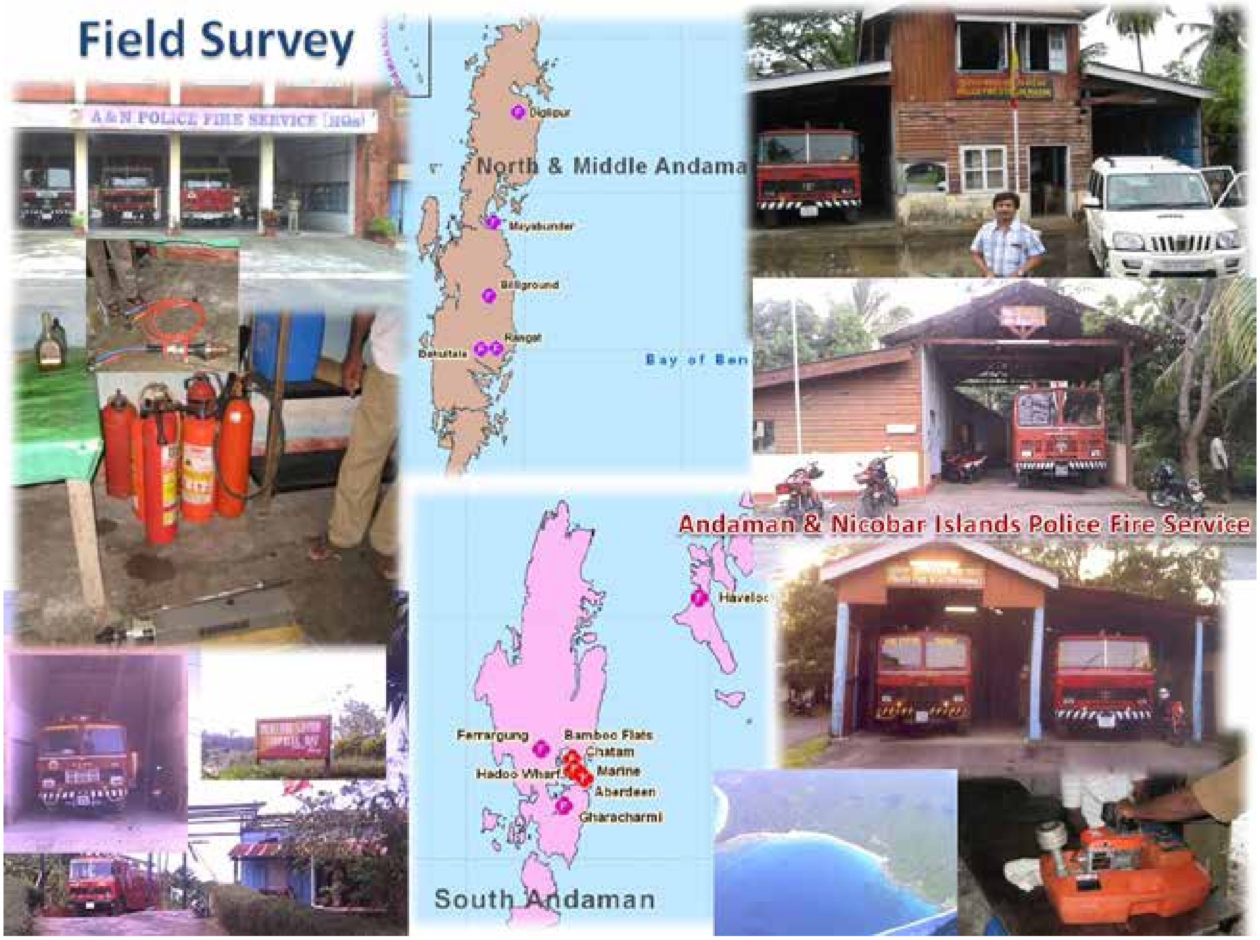
- Development of a questionnaire for Field Surveys of entire fire infrastructure and capacity reviews.
- GIS based Fire Hazard and Risk Analysis.
- Review of International and National Norms.
- Data Analysis to assess Gaps in:
  - o Number and locations of Operational Fire Stations
  - o Number of Firefighting and Rescue Vehicles and Specialized Equipment
  - o Number of Fire Fighting Personnel and Capacity of Fire –Infrastructure
- Summarise requirements by Fire Station, District, and State Level .
- Development of Fire Decision Support System (FDSS).
- Roadmap for Investment and Financial Plan for Next 10 Years.

I. Field Surveys for Fire Infrastructure Data

To collect and collate the information on Fire Infrastructure of all the States/ UTs, two detailed forms "Headquarter Data Collection Form" and individual "Fire Station Field-Survey Form" were developed. These forms were subsequently used for detailed GPS based field-survey of all the fire stations in all States/UTs for collecting detailed fire-Infrastructure information (Figure 1 and 2). The detailed information collected includes address of the Fire Station, name of the Fire Station In-Charge, emergency contact numbers, communication between Fire Station control room, public and headquarter control room; Fire Station building details including staff accommodation and barracks; fire fighting vehicles and specialized equipment; fire personnel, their duty pattern and pay-scales; water availability and water sources for fire vehicles, fire-risk in the jurisdiction of Fire Station and its geographical coordinates (latitude, longitude by using a GPS. All this information for each and every Fire Station has been digitally converted and is available through Fire Decision Support System (FDSS), which can generate a Fire Station report at the click of a button.

Figure 1: Field Survey of Jammu & Kashmir Fire and Emergency Services

Figure 2: Field Survey of Andaman and Nicobar Islands Fire and Emergency Services



II. GIS based Fire Hazard and Risk Analysis

In general, fire risk is defined as a combination of hazard potential, exposure, and vulnerability:

Fire Risk = F (Hazard potential x Exposure x Vulnerability)

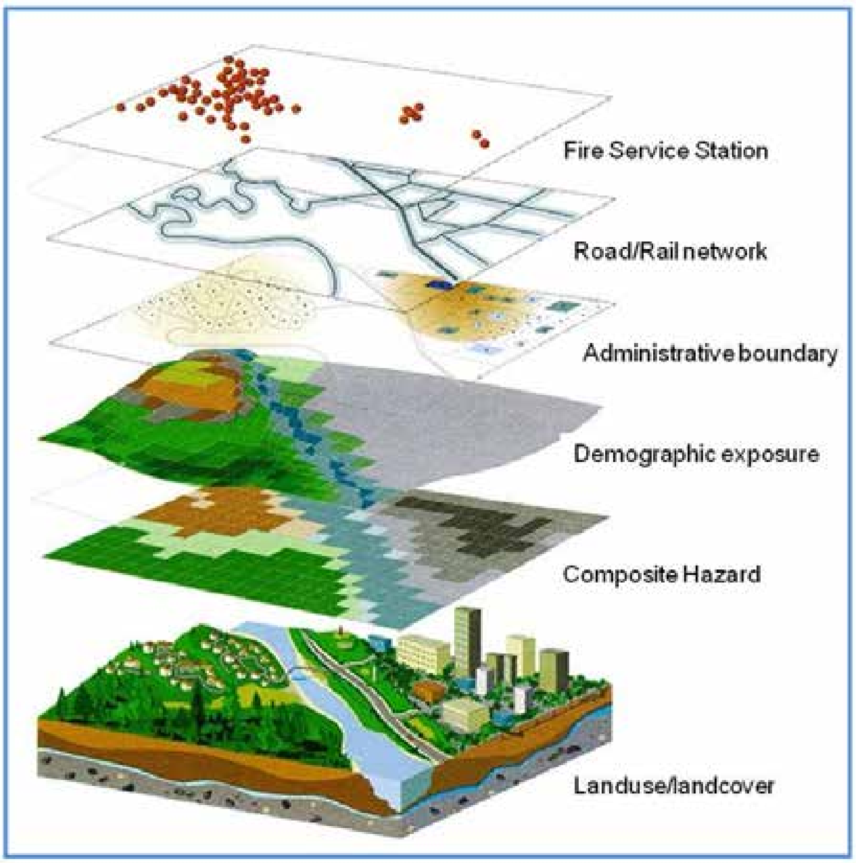
The occurrence of fire incidents that constitute a threat for the population and exposed infrastructure of a certain region is associated with economic and human losses, always as a function of the exposure conditions and the vulnerability of the exposed assets in that particular region. While conducting a fire-risk analysis, different natural hazards such as seismic (earthquake), climatic, and wind are considered. Additionally, mountainous zones are also considered in risk analysis due to increased fire risk from wooden houses and heating provisions in cold regions.

For estimating exposure and its vulnerability, detailed urban agglomerate classification maps generated from high-resolution satellite images have been used. With the help of remote sensing techniques applied on high-resolution satellite imageries, various types of urban agglomeration areas have been demarcated. These include urban, semi-urban, building blocks, and industrial & rural villages' built-up areas of different densities (high, medium, and low). For exposure vulnerability, four different layers such as population density, residential built-up areas, high-rise building block density, and industrial areas have been developed individually at the district level. For assessing fire risk, both absolute built-up areas in sq km as well as built-up areas percent (ratio of built-up areas to the total area) are considered as important parameters. It is obvious that there are much higher percentages of residential built up areas as compared to industrial areas in various districts. However, presence of industrial areas in a district has a significant influence in assessing fire risk. Hence, industrial areas in absolute terms (sq km) have been considered in the risk ranking[2].

In order to assess the impact of each exposure to a vulnerability type, a vulnerability score/ ranking has been assigned to each layer at their base unit. The vulnerability score represents the level of vulnerability (very high to negligible) of a specific type of exposure in response to the occurrences of small and medium fire incidents. The natural breaks, in value distribution are considered for defining the ranking class. After developing ranking of individual units of hazard and exposure vulnerability, GIS layers have been overlaid on top of each other and a spatial analysis has been performed for integration in GIS environment. For combining hazard and risk, Weighted Factor Analysis (WFA) in GIS environment has been performed (Figure 3).

Weighted ranking scores have been used in the integration analysis and quantified risk distribution for each district. Values of weighted factors depend upon the importance of a particular hazard/ vulnerability class in risk analysis. For integration of hazards, equal weights have been assigned to wind, seismic and climatic hazards, while double weights have been given to hill zoning. This is because, in hilly terrain, wooden houses and heating provisions in buildings increase the chances of fire-incidences, and thus have been given higher weights.

Figure 3: Overlay Weighted Factor Analysis for Fire Hazard and Risk Assessment



After obtaining integrated individual weighted scores for hazard and exposure vulnerability, fire risk categories have been obtained in quantitative terms by further integration of hazard and exposure vulnerability. It is obvious that in the occurrence of the number of fire incidents in a given district, exposure vulnerability has more importance than the prevailing hazard. Hence, in quantified integration, higher weights have been assigned to exposure vulnerability. The quantified numeric values of district risk scores are again grouped into four descriptive categories of district level risk ranking (very high, high, medium, and low). As one can understand that fire risk is not uniformly distributed throughout the districts in both urban and rural areas. Considering this fact, GIS based risk analysis was conducted, based on distribution of population agglomeration by defining built-up areas into different risk categories, such as high-density urban, low-density urban, sub-urban, and village. Moreover, distinct demarcated industrial areas have also been considered in the analysis.

Review of International and National Norms

To estimate the gaps from the existing position in terms of number of Fire Stations and their appropriate location, the RMSI team followed scientific and innovative GIS based response time network analysis approach involving various norms and regulations. Various international and national norms on response time were reviewed. Response time is defined as "en route time (in minutes) taken by the fire fighting vehicle from the fire station to the fire emergency scene." Different countries follow different norms on response time such as:

- Germany: response time in urban areas varies from 8 to 15 minutes
- Japan: response time varies from 5 to 10 minutes, depending upon the location of the building
- USA: response time varies from (3-4) to 8 minutes
- United Kingdom: response time varies from 5 to 8 minutes
- India: Standing Fire Advisory Council (SFAC) norms recommended response time for first fire tender between 3 to 7 minutes respectively depending on risk category A, B, and C in urban area and 20 minutes in rural area. The norms also defined one Fire Station in an area of 10 sq km in urban area; and 50 sq km in rural area.

RMSI experts carried out a number of simulations using GIS based network analysis. With these simulations, it was demonstrated that SFAC norms contradict each other and suggested revised response time based norms for positioning a Fire Station, as response time will vary from place to place depending upon the road network as well depending upon the risk category, the recommended response time for first fire tender is 5 to 7 minutes in urban areas and 20 minutes in rural areas.

Summary Findings

As a whole, in India, there are about 3,000 operational fire stations spread over 36 States/UTs. Based on detailed demarcated built-up areas and GIS based network analysis (response time analysis), ideal jurisdiction boundaries were demarcated for all operational fire stations excluding areas served by other agencies, such as ports, airports, military cantonments, thermal/nuclear power plants, refineries etc. The remaining areas, not covered under ideal jurisdiction of operational fire stations, are also divided for ideal jurisdictions of new proposed fire stations. The requirements for firefighting and rescue vehicles and specialized equipment are based on ideal served population, population density, and built-up areas within ideal jurisdiction boundary.

Fire Station Gap Analysis

As per detailed GIS based analysis (Figure 4), as a whole in India, there is a requirement of about additional 1,300 Fire Stations in urban areas and about 4,250 Fire Stations in rural areas.

Hence this study found an overall gap of about 65% in terms of number of Fire Stations in the entire country (Figure 5). For this analysis, response time of 5-7 minutes in urban area and 20 minutes in rural areas was considered. With network analysis, ideal jurisdiction areas were delineated for all operating fire stations. In delineation of ideal jurisdiction areas, built-up areas such as various types of residential areas and industrial areas with estimated population were also considered. After delineation of ideal jurisdiction area, un-served areas (gaps) in urban agglomeration were identified. These un-served gaps were shown to be filled by new proposed urban fire stations. Similarly, rural areas of the country were covered with new rural fire stations. It may be noted that rural populations are sparsely distributed in various states/UTs. Hence, locations of rural fire stations were demarcated to the nearest relatively bigger village having population of more than 5,000 -10,000 or major roads intersection.

Figure 4: Overlay GIS-based analysis Response Time Analysis for Fire Station Gaps

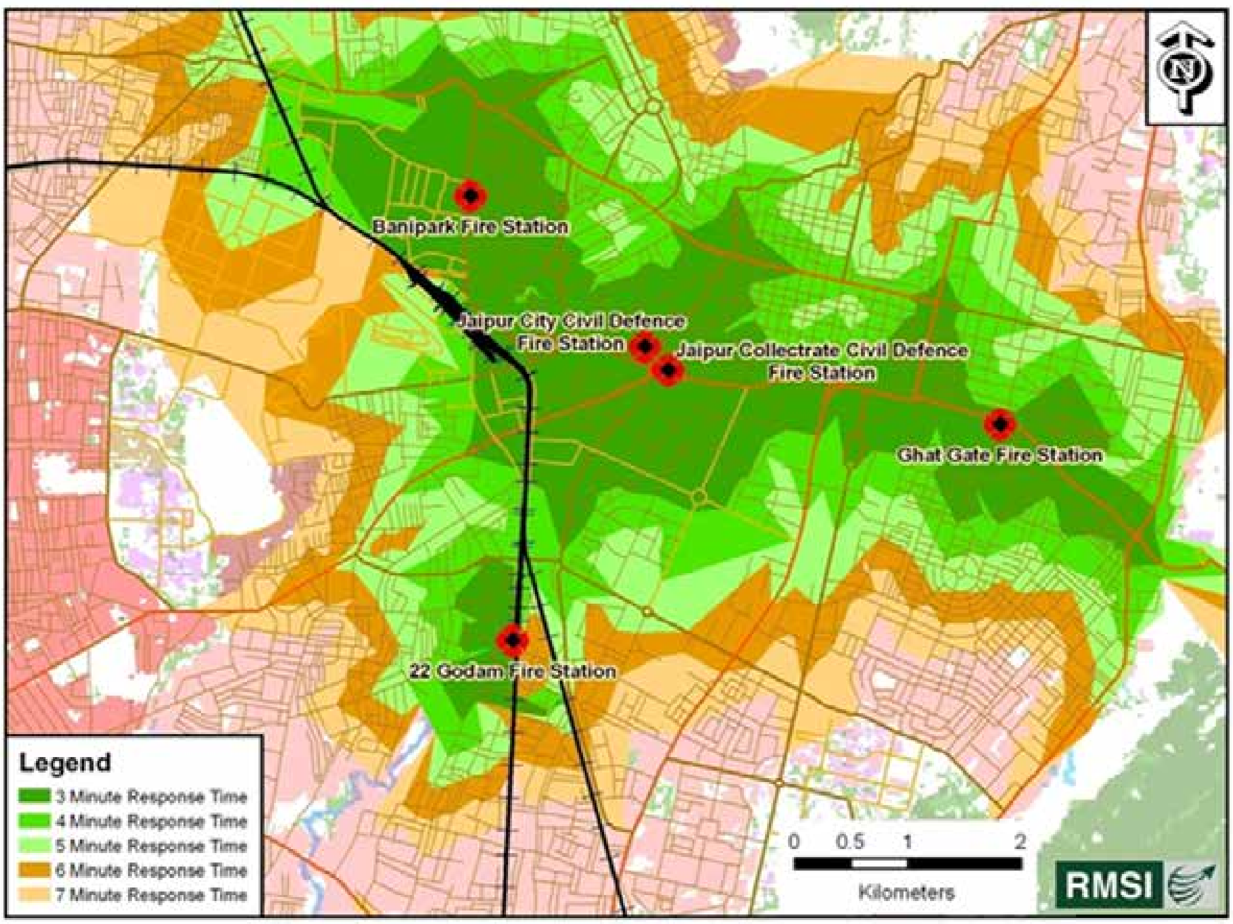
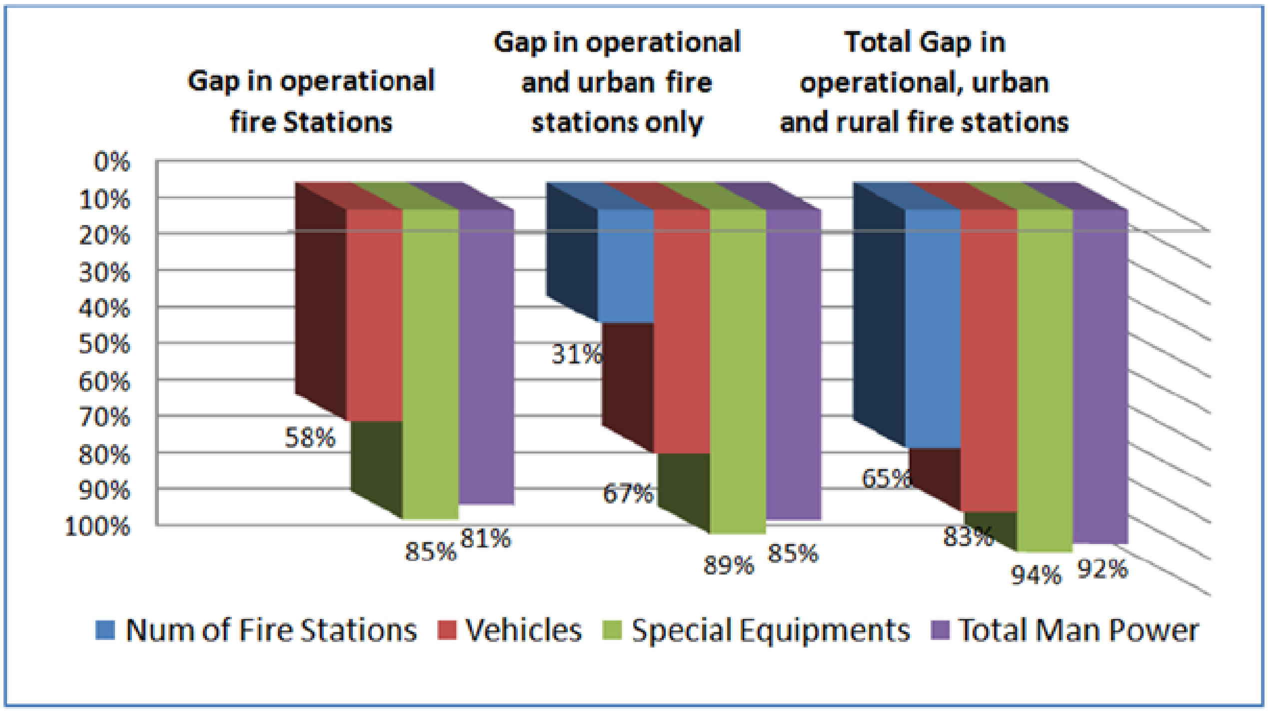


Figure 5: Gap analysis in number of fire stations, man-power, fire fighting vehicles and specialized equipment



Firefighting and Rescue Vehicles and Specialized Equipment Gap Analysis

These suggested modifications in SFAC norms helped in optimization of resources at district level of each States/UTs. This, study finds an overall gap of about 83% in the firefighting and rescue vehicles and about 95% in specialized equipment (Figure 5) for both operational and new Fire Stations in urban and rural areas.

Fire Personnel Gap Analysis

Administrative Reform Department (ARD, Delhi) norms based on duty pattern (double-shift) were used for optimization of the fire manpower requirements, which are different than SFAC norms. The duty pattern of fire personnel varies from state to state, i.e., from 8 hours, 12 hours and 24 hours. However, In this study, double shift duty pattern (12 hours) was followed for optimizing the fire personal gaps. Thus, as a whole in entire India, this study finds an overall gap of about 91% in fire personnel (Figure 5) considering double shift duty pattern[2].

Fire Prevention Wing

In addition to firefighting staff in State Fire Services, there is an urgent need for a dedicated and well-coordinated State/UT Fire Prevention Wing for inspection, awareness generation, and training in schools, colleges, hospitals, shopping malls, cinema halls, high-rise buildings, industries, govt. offices, public buildings etc. With the help of these the recurrence of the fire incidences similar to that at the Advance Medical Research Institute (AMRI), Kolkata, in terms of their magnitude and frequency can be reduced. Some of the states (e.g., Tamil Nadu, Goa, Delhi, and Andhra Pradesh) having a full-fledged dedicated Fire Prevention Wing and conducting awareness generation program frequently. As a whole, most of the states' fire services lack in awareness generation. Hence there is a need to develop a dedicated Fire Prevention Wing to make people familiar with common fire safety measures and their implementation[2].

Accordingly, to support the Head of Fire Services, additional officers at the levels of Director (Technical), Joint Director (Technical), Deputy Director (Technical), Chief Fire Officer (CFO), Dy Chief Fire Officer (Dy-CFO), Divisional Fire Officer (DFO), and Assistant Divisional Fire Officer (ADFO) have been suggested. It should be kept in mind that the number of officers suggested for above designations would vary from State to State or UT to UT depending upon various factors such as presence of urban agglomerations, industrial set ups including hazardous units, State's/ UT's current administration pattern etc.

Fire Station, District, and State Level Report Generation

The detailed report of Operational Fire Stations, District and State/UT level report for fire infrastructure and gap analysis is also available through the Fire Decision Support System (FDSS), which can generate reports for each Operational Fire Station, district.

Roadmap for Investment and Financial Plan for Next 10 Years

The other tasks include the development of Investment and Financial Plan, Institutional Assessment & Capacity Building Plan along with a dynamic web-based Fire Decision Support System (FDSS). The detailed investment and financial plan at State/ UT level includes estimation of capital cost for infrastructure, firefighting and rescue vehicles, and specialized fire and communication equipment. The recurring expenditure cost includes fire personnel cost depending upon pay-scales at various levels; staff uniform cost, and personal protective equipment (PPE); annual vehicle and specialized equipment maintenance cost, petrol, diesel, and lubricant (PDL); building maintenance; office and training expenses etc. The detailed roadmap and investment plan for the next 10-years include both capital and recurring expenditures.

Development of Fire Decision Support System (FDSS)

FDSS is a dynamic application, aimed at supporting decision makers take optimal decisions on complex tasks, such as resource prepositioning, gap analysis, prioritization, and resource optimization along with the day-to-day tasks. The most important aspect of FDSS is that it enables the apex fire management authority to provide the entire country's fire agencies' information on a single platform (Figures 6 and 7). Figures 8 and 9 present sample page of district infrastructure report and FDSS Gap analysis report.

Figure 6: FDSS Architecture - A smart client application

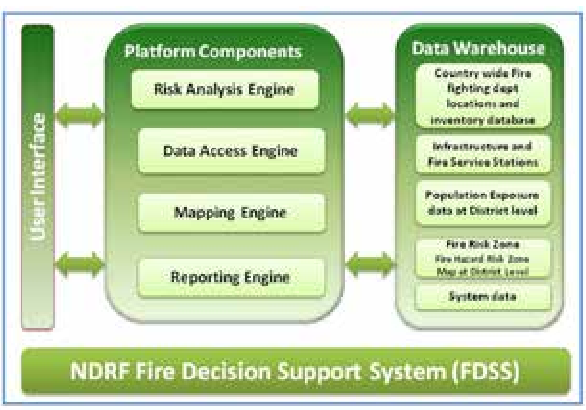


Figure 7: FDSS User Interface

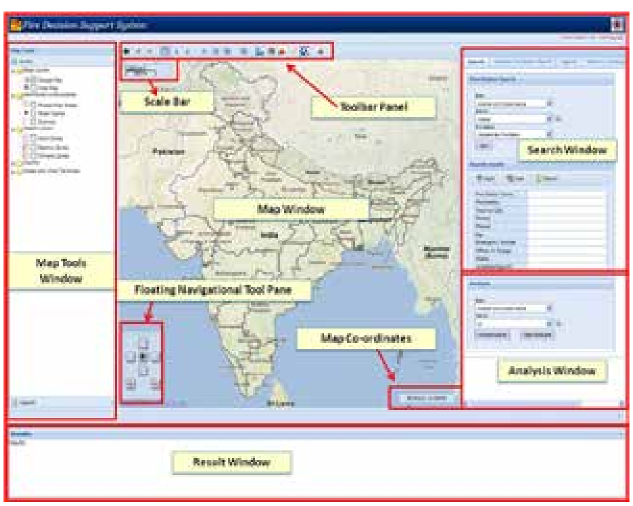
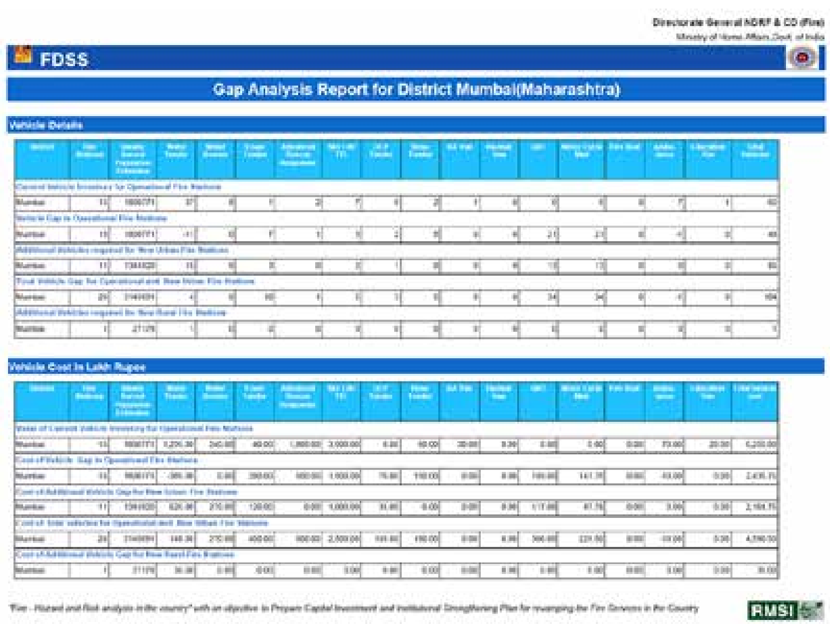


Figure 8: FDSS District Infrastructure Report

Figure 9: FDSS Gap Analysis Report



Benefits

The outcomes of this unique study are helping the Fire Cell in the directorate of NDRF and CD, MHA at the apex level as well as directorates of all the States and UTs, to:

- Achieve an inventory of fire infrastructure on a single platform for future development and growth of fire and emergency services in India.
- Understand the risk to people and infrastructure due to the growing vulnerability and the declining sufficiency of available firefighting infrastructure.
- Facilitate comprehensive financial analysis, automatic report generation at Fire Station, District, State/UT, Country level through FDSS.
- Identify comprehensive techno-financials requirements of each state/UTs.
- Know capacity building requirements both in urban and rural areas by prioritization of new proposed fire stations, and avenues for fund generation.
- Develop a National Fire Risk Management and Financing Strategy for revamping of fire services in India.

Way Forward

Despite optimization at each stage, there are significant gaps in the required number of new Fire Stations, trained fire personnel, fire-fighting vehicles and specialized equipment both in urban and rural areas. Specials efforts are needed to fill these gaps in all the Fire and Emergency Services in the country by implementing the recommendations of this study in all earnest both at the national (Directorate of NDRF&CD, MHA) and State/UT levels[2].

References

1. NDMA (2010). National Disaster Management Guidelines—Scaling, Type of Equipment and Training of Fire Services, draft report, 180 pp, draft, 2010.
2. Gupta Sushil (2012). National Report on Fire Hazard and Risk Analysis, Infrastructure and Institutional Assessment, and Key Recommendations, Final Report, submitted to Directorate General NDRF & Civil Defence (Fire) Ministry of Home Affairs East Block 7, Level 7, New Delhi, 388 pp. In total, there are 39 reports published as part of this study, which are available at http://ndrfandcd.gov.in/Cms/Firehazardandriskanalysis.aspx

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