Leveraging Geospatial Technology in Disaster Management

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Abstract. The increased frequency of disasters has become a peril to human habitation across the globe, and leveraging Geospatial technology for effective disaster risk reduction and management for all phases of disaster management is the way forward. Geospatial technologies have to be leveraged to facilitate disaster management by producing models for visualisation of the effect of the disaster, efficient methods to mitigate and effectively deploy teams to undertake rescue, reconstruction and rehabilitation. Karnataka State has been actively involved in Disaster Risk Reduction (DRR) through the inclusive cooperation of all stakeholders. The paper describes Leveraging Geospatial Technology Innovations in Disaster Management, the conceptual geospatial database design envisaged, and the decision support tools developed for emergency management. The State has developed Karnataka State Disaster Management Information System (KSDMIS), a Geospatial Web Application for Collecting Data on Disaster Events. KSDMIS is a state-of-the-art technological disaster management technology with real-time infrastructure to collect & store data, analyse, communicate and auto-generate event-based Reports or Memorandum. The State has also developed the "Geospatial Enabled District Disaster Management Plan (GEDDMP)" System. GEDDMP system is a technology-driven solution designed and developed to create a Geospatial foundation by structuring information and generating plans for disaster management.

Keywords: Disaster management · Geospatial technology · KSDMIS · GEDDMP · Disaster risk reduction

1 Introduction

1.1 Disaster Scenario

Karnataka has been experiencing various natural disasters, both hydro-meteorological and geological, every year. The devastating weather phenomena have led to successive Drought, Flood, Hailstorms, Lightning, Strong surface winds and intense vertical wind shear, causing massive loss of life and property in the State. 80% of the Geographical area in the State has been frequently affected by Drought, and nearly 22% of the Geographical

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area is prone to moderate earthquakes. The State has 24% of its Geographical area prone to cyclones and heavy winds; landslides affect the areas with more than 30% slopes. The coastline of 359 km in the State is prone to sea-erosion and Tsunami; Hailstorms almost every year cause damage to crops, human lives and livestock.

Natural disasters have been causing massive loss of life and property in various parts of the country in recent decades. Having a vast geographical area and hosting a vast population, effective management of disasters is a humongous task. Lack of coordination and speedy address of rescue operations, mostly manually driven, is one of the major causes of human lives lost. Though we cannot prevent natural disasters, they could be managed effectively through proper planning.

1.2 Geospatial Technology

Geospatial technology has the exceptional ability to collect, store, analyse, and distribute information. All phases of Disaster management depend on data from a variety of sources. Relevant data has to be collected seamlessly, organised and displayed logically to determine the size and scope of Disaster management programs. During an actual disaster, it is imperative to have the correct data, at the right time, accessible and displayed logically to respond and take appropriate action. Disasters can impact all or several sectors of the Government departments. Emergency workers find it challenging to access interdepartmental staff and resources without this capability, resulting in disaster responders guessing, estimating, or making decisions without adequate information. Geospatial technology provides a mechanism to centralise and visually display critical information during disasters. By utilising geospatial technology, all departments can share information through databases on computer-generated maps in one location. Most of the data requirements for emergency management are spatial and can be located on a map. This paper will illustrate how Geospatial technology can fulfil data requirement needs for planning and emergency operations and how Geospatial technology can become the backbone of disaster management. Disaster management activities are focused on three primary objectives. These objectives are protecting life, property, and the environment.

Geospatial technology can be adopted to save lives and reduce damages in all aspects of emergency management. Responders who know where impacts are most significant, where critical assets are stored, or where infrastructure is likely to be damaged can act more quickly, especially during the “crucial golden hour”.

1.3 Geospatial Technology Innovations in Disaster Management

Geospatial Technology plays a huge role in disaster management because the features impacted by disasters are geographically located and have geographic addresses. Karnataka State is prone to numerous natural disasters. Frequent disasters have resulted in the loss of lives and livelihoods, caused immense damage to infrastructure and disrupted critical services. The socio-economic losses undo years of growth and development, primarily affecting the most vulnerable and marginalised populations. Hitherto, data on disaster loss, damage and expenditure are taken through physical/paper mode and in different formats like Excel, MS Word, PDF, images. The districts collating the data sets have been a cumbersome and time-consuming process. The collection of factual data on disaster events is necessary to assist with quick relief, rehabilitation, recovery & rebuilding, assessing the loss due to disaster, preparing the reports, event-based memorandum, and updating the Disaster Management plans. Further, the non-availability of centralised data hampers decision-making during emergencies, and it is difficult to monitor compliance on expenditure from SDRMF and NDRMF. Karnataka State Disaster Management Authority (KSDMA) and Karnataka State Natural Disaster Monitoring Authority (KSNDMC) have developed an integrated disaster database called Karnataka State Disaster Management Information System (KSDMIS) - An Geospatial web application for collecting data on disaster events for bringing uniformity in disaster classifications, criteria and parameters of loss and injuries to humans, livestock, loss of livelihood, and other capital losses including losses to private property and business.

Technology Automation and Artificial intelligence have advanced over the past few years. They have been solving real-world problems with close to human-like logical & analytic thinking with decision making. Being a technology hub of the world, India needs to adopt the technology-driven solution to effectively and efficiently contain and manage disasters and save precious lives and property. As the scale, complexity, & challenges in coordination and managing, disasters are enormous and often beyond human capabilities. It is logical to use such advanced technologies to mitigate the impact. Software technologies will also be able to process information and make logical decisions & judgements without getting affected by ad-hoc and unstructured impulses. The Geospatial-DDMP is a technology-driven solution designed and developed to create a Geospatial foundation by structuring information and generating plans for disaster management. A digital geo-information database and generation of State and District Disaster Management Plan through auto mode is a prime output of the Geospatial-DDMP platform. It enables to touch all aspects of disaster management and facilitates automatic response systems, decision making, tracking, documentation and 'lessons learnt' to mitigate risks in future.

2 Karnataka State Disaster Management Information System (KSDMIS) - A Geospatial Web Application for Collecting Data on Disaster Events

KSDMIS is a state-of-the-art disaster management technology with real-time infrastructure to Collect & Store data, Analyse, Communicate and auto-generate event-based Reports or Memorandums. The authentic information geo-stamped with GPS location & time is collected using the Web and mobile interfaces. The KSDMIS intends to dispense with the manual collection process and ensure collecting last-mile disaster-related data using appropriate technology that ensures transparency, data integrity, real-time data availability, and data collation. The KSDMIS enables the data collection from ground level to district level and State level in predefined standardised templates for data collection, updation and validation to ensure accuracy and quality. The data from KSDMIS will form the basis of hazard and vulnerability analysis and prepare the Annual report as mandated under Sub Section 2 of Section 70 of the Disaster Management Act, 2005. KSDMIS is crucial for assessing and tracking risks and progress towards resilience, without which the State cannot mainstream disaster risk reduction into developmental activities. It will also be a step towards implementing the Prime Minister's 10-point agenda plan to address disaster risks and Sendai Framework Disaster Risk Reduction. KSDMIS auto-generates the memorandum of Losses and damages by collating the geo-stamped data submitted from various field locations across the State, including statistics, maps, photos, and other documents related to the extreme event. KSDMIS uses a GPS enabled handheld Mobile to capture geo-stamped location and time details of a site with photo/audio/signature. KSDMIS has data collection templates to capture all details of losses, including human and animal loss, crop loss, infrastructure damages, industries, national highways, private properties, relief camp details, search and rescue operation, crop loss subsidy and housing assistance, monitoring drinking water supply & repair works using the SDRF/NDRF fund. The database created will provide help identifying the mitigation.

2.1 About Karnataka

Karnataka is India's eighth largest State in a geographical area covering 1.92 lakh km^2 and accounting for 6.3% of the country's geographical area. The State is delineated into 31 districts and 227 taluks spread over 27,481 villages. Bengaluru is the capital of Karnataka and the city known as the Silicon Valley of Asia due to its flourishing Information Technology industry. The location of Karnataka state is provided in Fig. 1.

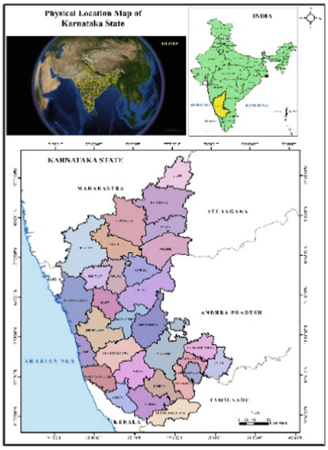

Fig. 1. Location map of Karnataka, India, where the application shall be adopted.

2.2 Objectives of KSDMIS Application Software

Data collection in real-time/near real-time in predefined templates from the disaster-affected area. Geospatial view of damaged areas and helping to plan appropriate mitigation measures. Geospatial authenticated Memorandum generation for Government of India Submission. Calculation of losses under various categories and fund requirements.

Data authenticity by Geo stamping. The database will provide help in the identification of mitigation projects.

2.3 Benefits of KSDMIS Application Software

KSDMIS provides authenticated Geo-stamped information from the field. All information collected from the field is Geo stamped from the KSDMIS app, along with the survey and loss/damage details.

- **Real-time system:** The final report of losses and damages and memorandum can be generated in real-time as the Geo stamped photos get synchronised to the servers directly from the field.
- **Ground-up (Village level data):** The data is collected from each location and tagged to the village level. The software reporting engine provides granular information and is statistically summarised at Panchayat, Taluk, District, and State levels.
- **Database driven:** Data management is structured with information tagged with location masters and standard jurisdiction IDS (District, Taluk, Panchayat and Village). Digital database provides a framework to generate MIS reports and identify gaps in procedures automatically.
- **Repeatable:** Database can be dynamically updated from the App and web portal where respective districts can add or modify information. Continuous update to information ensures repeatability and up-to-date information.
- **Traceable and avoids duplication:** Since the data collection and reporting are encompassed in a single software system and authenticated GPS and photographic information, it helps traceability and avoids duplication.
- **Last-mile data collection from Mobile Phones:** Native mobile App helps collect data from the field. The App is resilient to no-network zones and is designed to work in the field. The data is stored on the phone and synchronised in no-network whenever network/wifi becomes available.
- **Standardised surveys:** The survey engine of the system can automatically generate mobile and web surveys from a template. The surveys get synchronised to the mobile App. This ensures that the data collection is standardised.
- **Tamper Proof:** Photographs with GPS ensure that the data cannot be tampered with as there is a reference to validate the same.
- **Reduce human errors:** Since the reporting engine is software-driven and automatically generates reports depending on the user profiles, it reduces human errors and calculation mistakes.
- **Accessible:** Web-driven system makes the information accessible to various user groups depending on the privilege over the Internet.
- **Accountability:** Since the data is submitted from the place of the event by a user who has unique access & login credentials, it makes the submitters accountable for the accuracy of the data.
- **Low cost:** Memorandum & report generation is at the click of a button with minimal manual intervention, avoids paper trails, saves time and is cost-effective. The App runs well on low-cost devices and has low RAM and CPU requirements.

2.4 KSDMIS Application Software Structure

The KSDMIS has been designed with distinct features for accurate and authentic data collection with ease from the field by the designated officers, periodically updating data and generating event-based reports or memorandum.

KSDMIS system has three technology components. They are,

1. Handheld GPS mobile which can capture field information such as Forms/questionnaires, Photo/video/audio and Signatures on touch screen and automatically transfer the same to a Geo-information database wirelessly through 3G/GPRS
2. Geo-information Database which can store field data classified under jurisdictions and surveys
3. Backend system interprets data from geo-information database and Auto-classifies survey data, auto-computes statistics needed for submitting a memorandum, and generates memorandum, MIS reports, and maps.

The field staff performs all data collection, survey, monitoring, authentication, feedback, and disaster response activities using the login protected handheld mobile. The data is finally presented as a webpage through the backend interface or periodically auto-generated documents (Memorandum). For the user, there are two interfaces to submit the data: the Mobile interface (Android) and the Web interface. Both interfaces have the same secure logins for each district. Field data is submitted using a mobile interface (level 1 survey) with photographs and GPS coordinates. Level 2 surveys can be added from the Web to update the status. Each data is Geotagged at a village/ward level. There are 33 Annexures such as Human Death, Animal Loss, Road Damage etc. These annexures are presented on the website & mobile App as survey forms are filled and submitted. The schematic diagram of data and information communication technology is given in Fig. 2.

2.5 Mobile Interface for Data Collection and Updation

The user can upload and submit the information directly from the field and update information periodically. For example, this module can submit periodic progress if a building is added and under construction. The periodic data survey is generated as per the definition in web admin - upon 100 surveys with 100 fields are provisioned for the periodic data survey.

The mobile interface to the KSDMIS has three types of privileges for the users.

1. *Location Restriction:* This allows the user to be locked to a location at the District level/Taluk level/Town Level/Panchayat level/Village level. The user can only submit data for the location assigned. This provision acts as a Geo-fencing for collecting authentic data from the field by an authorised field officer within his jurisdiction or administrative boundary.
2. *Department Restriction:* The user to collect data pertinent to a particular department only. The department, in turn, can set surveys for data collection and periodic updates.

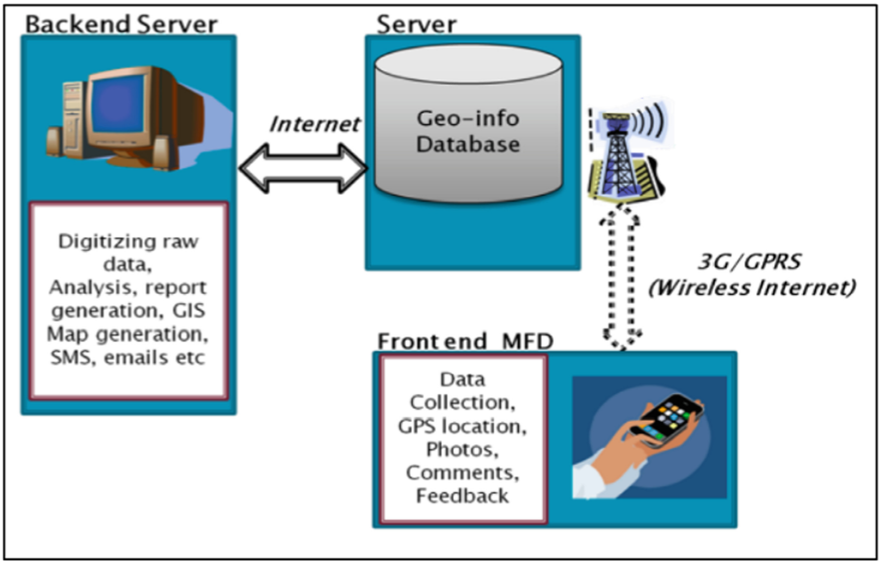

Fig. 2. Data and Information Communication technology

If the department is assigned to a user, only the surveys/periodic data defined and collected in the department can be accessed by the individual user.

3. *Surveys and Periodic Data:* This privilege supersedes department privilege and sets the surveys/periodic data to access or submit.

2.6 Web Interface to the KSDMIS Application Software

The web interface to the KSDMIS has the following features for data collection, updating.

- The web interface enables the user for periodic data submissions for each survey.
- It has provisions for collecting or updating 100 periodic data types, each having 100 data fields.
- Import periodic data definition using excel format (defining each field type and assigning the reference survey). Field type can be photo, Signature, selfie, text number, drop down, date, time etc.
- Sync between Web and Mobile for data definition and uploads.
- Define and assign surveys/systematic data collection to each department.
- Views to see periodic data submitted by the user.

2.7 Adopting Geospatial Technology in KSDMIS

The user will adopt the KSDMIS application at State, District, Taluk and Village level to survey and collect data, assess the loss and damages incurred during a disaster, geotag the validated data and auto-generate a memorandum as an end component. The data so achieved shall be uploaded and verified by taluk and village administration, followed by district level approval. The village-level field staff performs all data collection, survey, monitoring, authentication, feedback, and disaster response activities. The surveyed data is geotagged to the interface with location wise information collected at the disaster affected location. The flowchart of KSDMIS Technology adopted is given in Fig. 3.

2.7.1 KSDMIS Report Generation Mechanism

KSDMIS document engine has two parts viz. Static data is entered as a one-time exercise, and dynamic data is collated from field data entered by various districts using a Web or mobile interface.

The type of data entered into the system is classified as

a. Manually entered using a doc link interface which facilitates easy entering and formatting of data
b. data is obtained dynamically from an API link or URL, and such data is inserted into the document using unique tags specially architected for the purpose. Such an interface facilitated integration with external data from other departments.
c. Architected special tags can be translated to Database hooks. Such database hooks can be of a single value or even a table with images, geo-stamped photos, links etc. They also introduce the opening of GPS navigation by scanning QR codes. Such QR codes are dynamically created and inserted into the document. This enables viewing detailed information from a printed document.
d. Complex Mathematical Expressions can be added to the document based on the database tags. Such expressions can be used to evaluate dynamically - the sum of a list of tags (values), the sum of columns, rows of tables or evaluating a formula dynamically.
e. When a block is marked as a loop, it will inject the block values loop for all districts and value-translated pages into the document. For example, when marked as a loop block, the standard expenditure sheet for each district will be evaluated, and pages will be injected for all districts in the document.

Memorandum has Four parts, namely, Static Information (common objectives, definitions, SOPs, checklists) Meta Information (State or District or Taluk Specific Static Content), Statistical (Dynamic) and Detailed Survey Information (Dynamic).

2.7.2 Approval Flow - There is a Strict Three-Step Approval Process in the System to Improve Accountability and Quality of Data

(1) The field level of users (Uploaders) submit information from the field at a village level and review their submissions. If there is an error in the submission, the system allows a re-submission.
(2) The next level of users (Verifiers) can verify individual submissions made with their Taluk/Block. The verifiers can mark each submission as Approved/Rejected/To be corrected. The uploaders take action to correct any items which verifiers mark.
(3) The third level users (Approvers) review the data, report and summaries at a district level and approve/reject surveys.

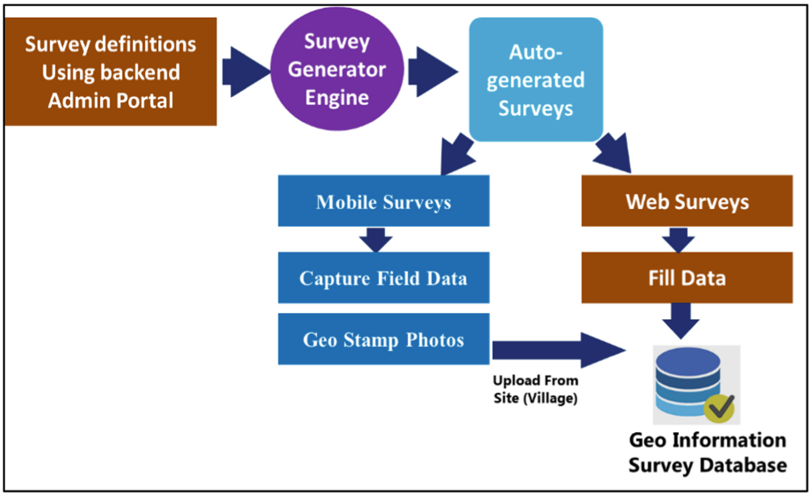

Fig. 3. Flowchart of KSDMIS technology adopted

The reports and memorandum are generated only for the approved entries. Once an item is marked as approved, the uploader cannot resubmit/alter the submission unless marked for correction by the verifier.

3 Geospatial Enabled - District Disaster Management Plan – GEDDMP System

Geospatial-DDMP is a state-of-the-art disaster management technology with real-time wireless infrastructure to collect, store, analyse, communicate, coordinate & present authentic information, geo-stamped with GPS location & time, using a web-based geo-information database/framework. Geospatial Enabled DDMP auto-generates a District Disaster Management Plan (DDMP) using field resource and personnel information with maps of geo-mapped resources. It uses GPS enabled handheld Mobile to capture geo-stamped location and time details with photo/audio/hand-written notes. To & fro data communication is possible wirelessly from the geo-information database to the handheld device using a mobile network.

The conventional disaster management system has limitations like limited access to real-time, authentic, quantifiable information leading to communication gaps or even miscommunication, Lack of information and infrastructure for preparation & communication and difficulties to connect Standard Operating Procedures (SOPs) with the ground reality.

Whereas the Geospatial Enabled DDMP helps to overcome the above limitations with

- Accurate, tamper-proof data authenticated through GPS location and time
- Real-time information transfer wirelessly with a feedback mechanism to the provide updated, relevant data/strategies to field

- Generating and disseminating Instant messages
- Real-time event capture including photo, voice, hand-written notes, forms, status
- Auto-generation of analysis reports, statistics saving manual labour, human errors, paper trails
- Monitoring of reconstruction, restoration and compensation
- Database Archive for future disaster mitigation, accountability, traceability

Since Karnataka is India's IT hub, it leads the way to leverage the latest technology to effectively and efficiently manage Emergencies and Disasters to minimise losses to life and property.

Geospatial Enabled DDMP system given in Fig. 4 will enable the stakeholders to effectively map all the essential resources and associated resource personnel during "peacetime" so that disaster response is predictable, planned, and planned executed with accurate and up to date information.

GEOSPATIAL ENABLED DDMP system facilitates the execution of the disaster management cycle by interfacing each aspect of disaster management with a geo-information database and a real-time data communication infrastructure. During preparation, the data is stored in the geo-information database, and data is used for response and recovery.

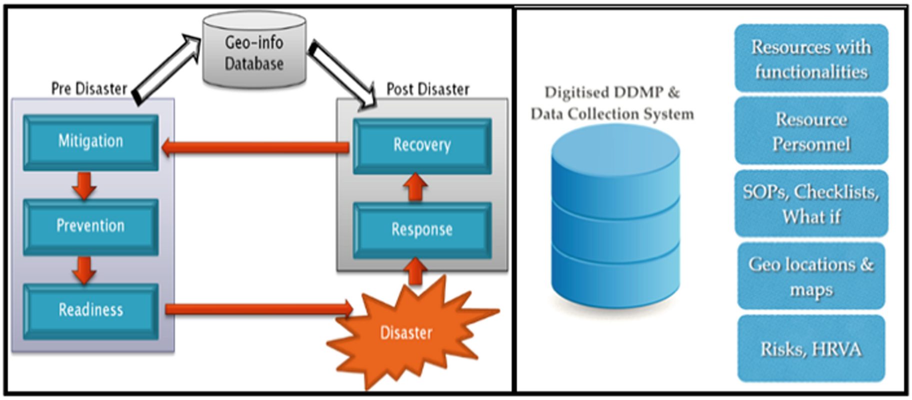

Fig. 4. Geospatial technology system in disaster management

3.1 Operation Strategy

Field data collection is continuously performed by the field officer by collecting activity details through form filling. The teams use existing radio wireless Communication if the mobile network fails to operate. However, status update & data collection is continued on the Mobile. The data is stored on the Mobile and gets synchronised with the server whenever the Mobile gets back in the network range. The operation strategy and what if analysis are given in Fig. 5 and 6.

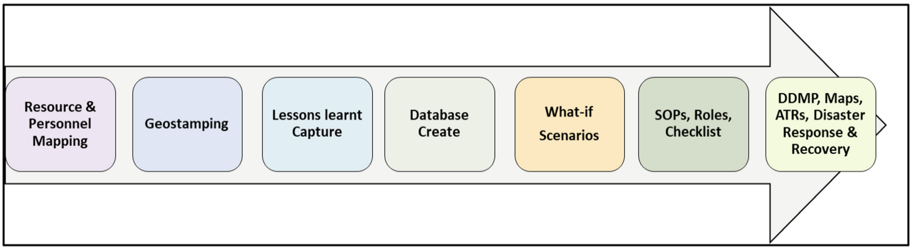

Fig. 5. Operation strategy

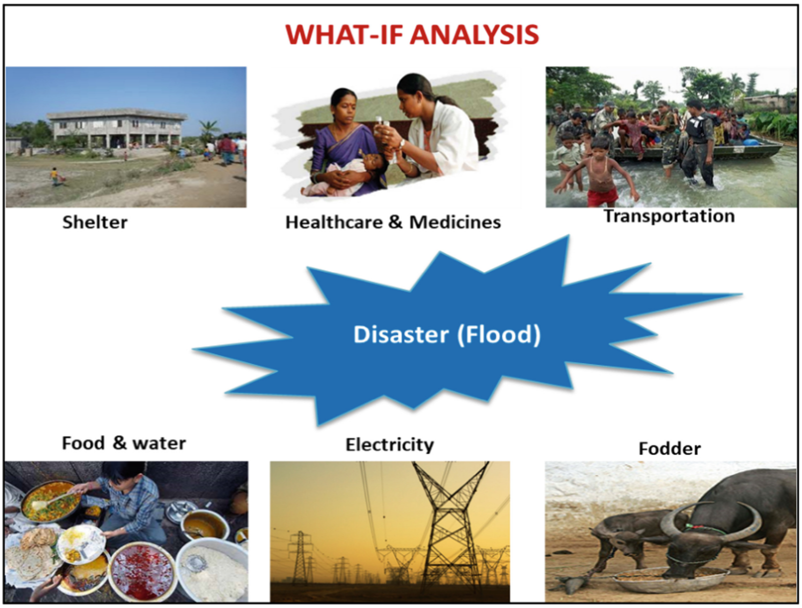

Fig. 6. What if analysis

Resource data is analysed, reviewed and tagged into the roles and responsibilities of departments/officers. Based on the officer's role and the associated activity, the appropriate field resource information will be presented (with the real-time status), enabling a better judgment call during the disaster.

Login ID	Officer Name	Disaster type	Role ID	Description	Resource Info
9012	Shyam P	Flood	RL5467	Take victims to nearest PHC	Click to view Resources

Resource ID	Area	PHC Type	No. of Doctors	No. of Beds	Contact
PHC123	Sindgi	24/7	2	5	+919087265342
PHC124	Sindgi	Normal	1	0	+919087388383

According to the role, associating the resource information to the Role ID provides up-to-date field information to the officer. A similar process takes place for checklist generation, through auto-mode from the database, for each department/authority to cross-check and verify preparedness. As soon as a disaster strikes, relevant geo-information data is made available to the field staff. The field staff execute the activities and update the server with the status using the handheld device. The controller or backend officer reviews the status and provides feedback or follow-up issues with other departments.

3.2 Continuous Data Updation

Roles and Responsibilities would be assigned to designated personnel in each department to keep the database up-to-date. Periodic reminders are sent to check and update the system with relevant changes in the data. If no change is required during an incremental update cycle, an explicit sign-off mentioning 'No Update Required' would be expected to ensure that the system is consciously kept updated.

Based on the updated data, the GEDDMP will be revised periodically. The enhanced GEDDMP would contain the sections for updated information on District Profile, Disaster Vulnerability, Telephone Directory of Resource Personnel, Directory of Resources, Duties and Responsibilities, Disaster types, Resource Maps, FAQ, Dos & Don'ts and Checklist & Annexures.

3.3 Benefits of Geospatial Enabled-DDMP System

Simplified Procedures: The manual process of preparing the GEDDMP where all information needed to be revalidated year on year, updating the telephone numbers, and capturing resources were very cumbersome. However, with the GEDDMP, pre-disaster management data collection is structured and standardised by dynamically updating a web portal where departments can add or modify information and click a button. Additional features like generating the roles and responsibilities of various stakeholders, Resource maps, faster communication, alerts and warnings to authorities, departments and local people who are likely to be affected are simplified to a great extent.

Increased Efficiency of Outputs/Processes and Effectiveness of Outcomes: Automated generation of GEDDMP decreased human intervention: saves time, effort, cost, Accurate and up-to-date information, defining clear roles and responsibilities, achieving real-time information from the field eases data collection process which makes instant update possible, automatic generation of MIS reports from the digital database and identify gaps in procedures, provision to incorporate lessons learnt for continuous improvement and continuous updation of information ensures repeatability.

Sustainability of the Initiative: The significant role of Geospatial technology in the deployment, making the initiative repeatable with minimum human intervention. Low cost of sustaining and operating the technology, as the initiative is modelled for comprehensive and holistic disaster management and can be adopted by other states Continuous updating of information and feedback loop with lessons learnt will provide means to improve the system continuously.

Improvement in Delivery Time of Services: Periodically updation/maintenance of GEDDMP during peacetime. A centralised database provides scope for improved communication and more precise role definition across various departments. Automatic generation of GEDDMP, Maps, and MIS reports for disaster management from the digital database at the click of a button. Geospatial-DDMP is truly a next-generation disaster management technology system and overall aims to minimise the loss of life and property with tools & means to holistically and comprehensively manage disasters.

Better Beneficiary/Citizens' Feedback: The Geospatial Enabled DDMP will be available on the Web for all beneficiaries to download and use. The User-friendly data updations by various stakeholders and auto-generation of GEDDMP is a good feature.

3.4 Geospatial Technology for Different Phases of Disaster Management

Geospatial Technology provides accurate spatial data and insights to disaster response strategies and visualises critical vulnerabilities and damage.

A disaster management plan would be more efficient when integrating Preparedness and Planning with Geospatial Technology. Adopting GIS into all the phases of disaster management planning presents an opportunity to prepare and act better during relief efforts through greater efficiency.

Geospatial data helps users to understand the impact of potential damage and further anticipate resource utilisation during an emergency. The line departments access real-time information with GIS-based dashboards and live maps to make informed decisions. We can foster risk analysis, situational planning, recovery operations, and enhanced collaboration with GIS technology. The Schematic diagram depicting pre-disaster and response phase based on Geo-Spatial DDMP given in Fig. 7 and 8 (Fig. 9).

3.5 Geospatial Enabled DDMP Application Software Structure

Geospatial-DDMP System Has Three Technology Components

- Handheld GPS mobile which can capture field information such as
- Forms/questionnaires, photo/video/audio and Signatures on a touch screen and automatically transfer the same to a Geo-information database wirelessly through 3G/GPRS

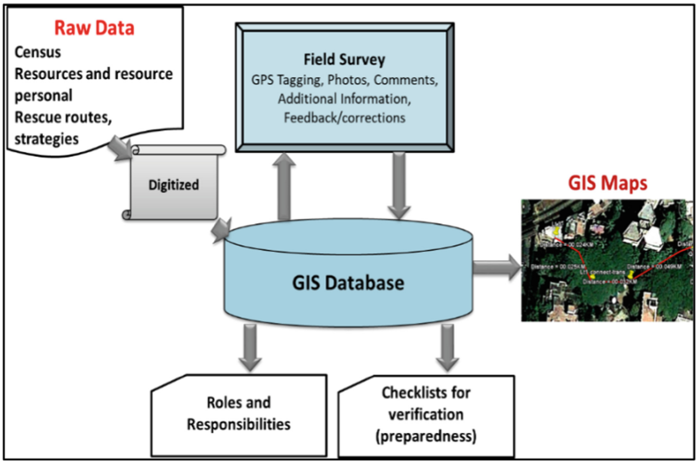

Fig. 7. Geospatial Enabled DDMP - pre-disaster phase

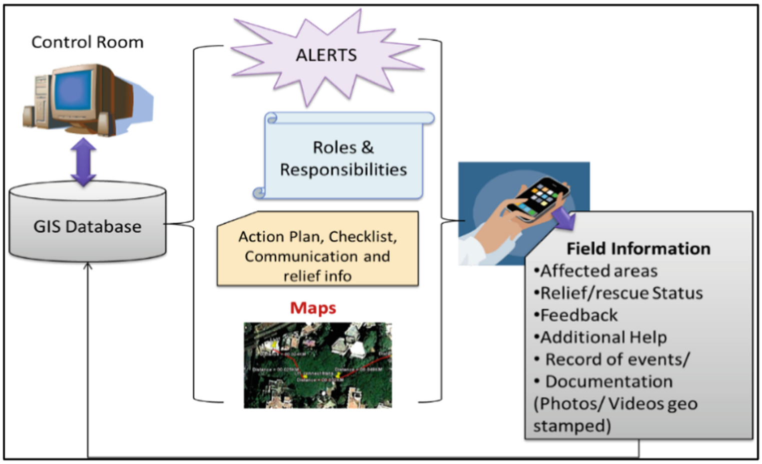

Fig. 8. Geospatial Enabled DDMP - response phase

- Geo-information Database which can store field data or existing digitised data as layers
- Backend system which interprets data from geo-information database and
- Auto-classifies resources
- Auto-assigns resources to roles/responsibilities of Resource Personnel
- Generates DDMP, reports, maps
- Communicate actions, activities, reports to all concerned via the Internet

The field staff performs all the data collection, survey, monitoring, authentication, feedback, and disaster response activities using the login protected handheld mobile device. The data in the geo-information database are stored as layers that can be used for access,

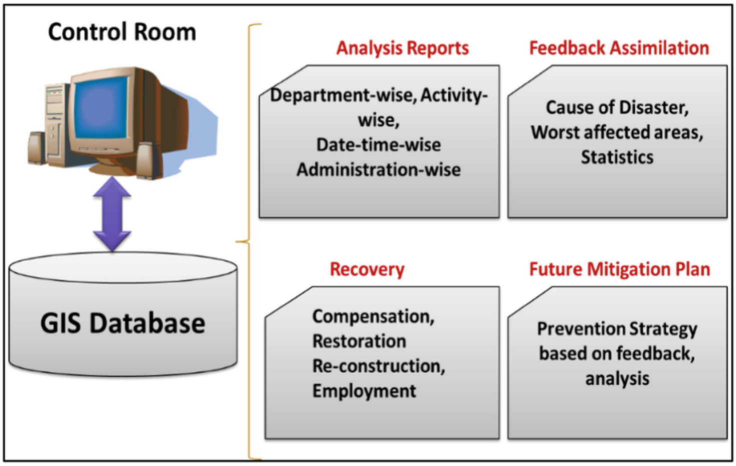

Fig. 9. Geospatial Enabled DDMP - post disaster phase

further analyse or present various combinations and interpretations. The data is finally presented as a webpage through the backend interface or periodically auto-generated documents (DDMP). The Data and Information Communication system are given in Fig. 10.

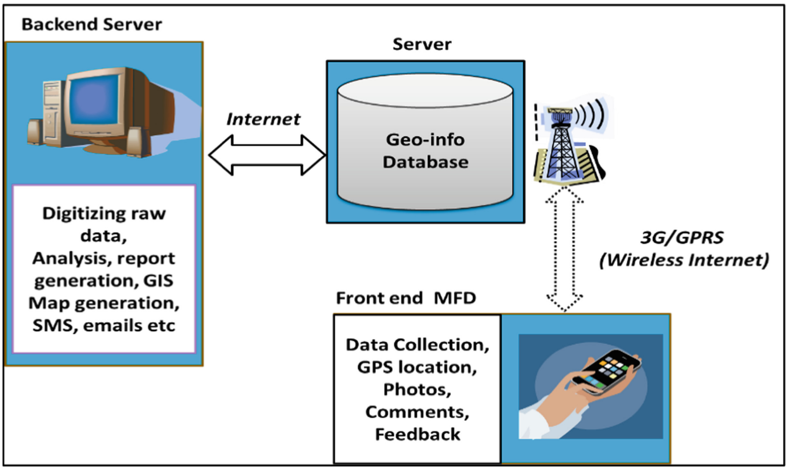

Fig. 10. Data and Information Communication system

3.6 Core Technology of Geospatial-DDMP Application Software

The DDMP has four parts. A user-friendly admin panel will help define various headings and subheadings, Formatting text, inserting tables, links etc. Central Admin Team will fill in DDMP Static Information. Images can be directly inserted into the textbook and formatted.

DDMP Meta Information: District Logins will be provided for entering this Metadata. The users log in, fill in specific information, and then insert HOOKs into the document.

DDMP HOOKs can insert Single computed value, multiple values in the form of a table, Loop a section for each district, fetch data and insert tables or single values, Evaluate expressions & formulas dynamically.

Dynamic information is obtained primarily from surveys. The survey information is used to create statistics or display tables using HOOKs. The system allows dynamic information to be inserted anywhere in the document using HOOKs.

DDMP Surveys: Logins are created for each department in each district, the district user logs in and fills the surveys, the surveys are restricted based on the department and district, and the survey database is used to generate the DDMP by using HOOKs.

3.7 Workflow

1. The admin personnel defines surveys as a one-time activity. Surveys can be Hospital, Ambulance, Vehicle, School,Building, Shelter homes, Material list etc.
2. The surveys are translated into software forms using the DDMP Survey engine, which translates the surveys to dropdowns, text & number boxes, date-time fields, photo upload, signature entry etc.
3. The survey forms are synced to the Web and mobile interface to facilitate users logging in, filling in, and submitting to a central server.
4. The data is stored in a geo-positional database with survey forms tagged with GPS coordinates, photos and signatures.
5. The admin also defines a DDMP template using the backend web portal, which specifies the META data (static), checklists, dos & don'ts and a template for the dynamic portion using DDMP HOOKs.
6. The DDMP generator reads the DDMP templates and survey form data from the geo-positional database to generate a real-time & live DDMP by looping the generator specific to each district. Along with DDMP, resource maps, resource directories, and associated statistics are also auto-generated.

The Workflow of Geospatial Enabled DDMP is given in Fig. 11.

3.8 Features of Survey Template HOOKs

Using the Template Definition module of Geospatial-DDMP, admin personnel can define multiple templates for DDMPs, including static and dynamic content.

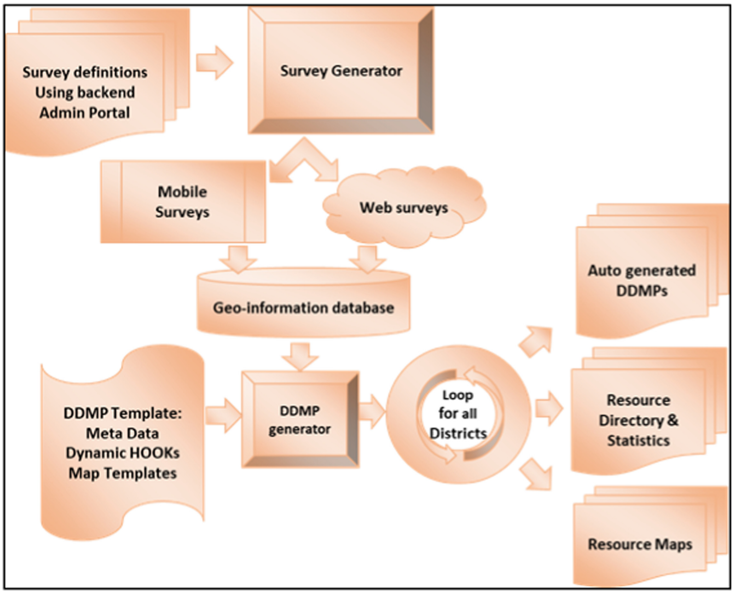

Fig. 11. Workflow of Geospatial Enabled DDMP

The type of information may be

- **Manually** entered using a doc link interface (WYSIWYG) which facilitates easy entering and formatting of data and facilitates.
- **Using API:** data is obtained dynamically from an API link or URL, and such data is inserted into the document using unique tags specially architected for the purpose. Such an interface facilitated integration with external data from other departments.
- **Using Database:** Architected unique tags (HOOKs) which can translate to database hooks. Such database hooks can be of a single value or even a table with images, geo-stamped photos, links etc. Also introduced was the opening of GPS navigation by scanning QR codes. Such QR codes are created dynamically and inserted into the document. This enables information from a printed document; details such as - enlarged photos, user info, date & time, navigation to the GPS location.
- **Expressions:** Complex mathematical expressions can also be added to the document based on the database tags. Such expressions can be used to evaluate dynamically - a sum of a list of tags (values), a sum of columns, rows of tables or evaluating a formula dynamically.
- **Loops:** If a block is marked as a loop, the block values will be looped for all districts, and value-translated pages will be injected into the document. This is useful when deriving state DDMP by consolidating existing district information.

3.9 Roadmap and Futuristic View

While the immediate focus of Geospatial-DDMP is to automate DDMP generation in "peacetime", it lays a foundation to add and expand the platform to further innovative and artificially intelligent (AI) technologies. It would focus on using the geo-information database, historical data, images, lessons learnt systems to integrate AI and IoT technologies to elevate the technology platforms. Some possibilities are explored to automate or use machine learning methods to integrate Bots, Robots and IOT devices with actionable plans. AI has made good progress in predictive analytics which can be lifesaving as data is often too immense for human effort (time & resource consuming). Often rescuers become victims, and they put their lives in danger, trying to save lives. Intelligent robots or AI-driven cars, boats, JCBs etc., can be lifesaving and, at the same time, will not put more human life at risk during rescue operations. The workflow of AI Technology is given in Fig. 12.

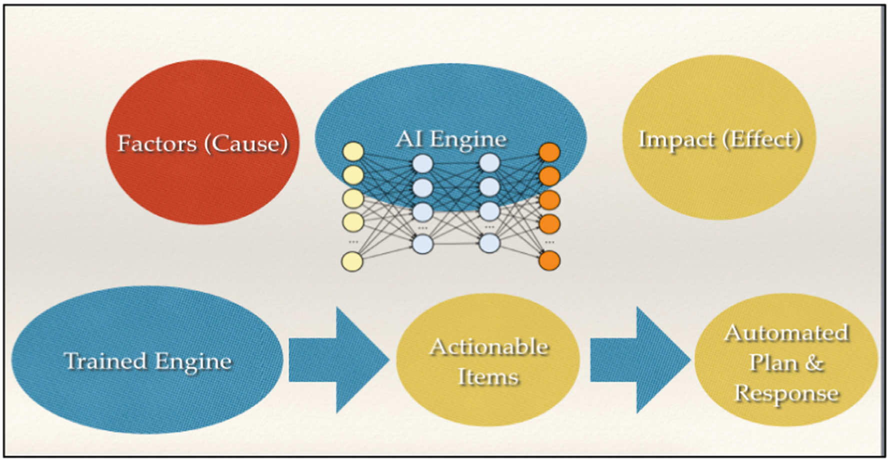

Fig. 12. Artificial intelligent (AI) technology

Historical records of cause and effect are fed into a deep learning AI system that can learn how disasters affect the people/environment based on the (input) conditions and predict future possibilities and probabilities of disasters in even unforeseen circumstances, making it very human-like logical thinking. Internet of Things (IoT) with sensors continuously collecting various data points like seismic readings, water levels, pollution, satellite imagery, social media messages, CCTV, photos and temperature sensors can feed into the AI system with real-time data for real-time planning, real-time decision making and real-time response and rescue.

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