used for laying models for conducting river behavior studies. Information derived from remote sensing can be used for other river morphological application studies like monitoring the existing flood control works and identification of vulnerable reaches, planning bank protection works, planning drainage improvement works etc. The changes in the river configuration can be monitored at regular intervals of time.

12.4.2. Case Study- Brahmaputra River Bank Erosion, Assam

For studying the erosion problem in Marigaon district post flood satellite data sets of 1987-91 and 1990-1998 were selected since high floods have occurred during 1988 and 1998. All the satellite data were geometrically rectified to the master map base for positional accuracy. Image enhancement techniques were applied on all the individual satellite data scenes to obtain better contrast among the features especially between land and water. The river configuration along with bank lines was delineated consisting of active river channel, sand and island. The bank lines were intersected to identify and estimate the amount of erosion and deposition at different pockets along the main Brahmaputra in Marigaon district in GIS environment. Figure 12.24

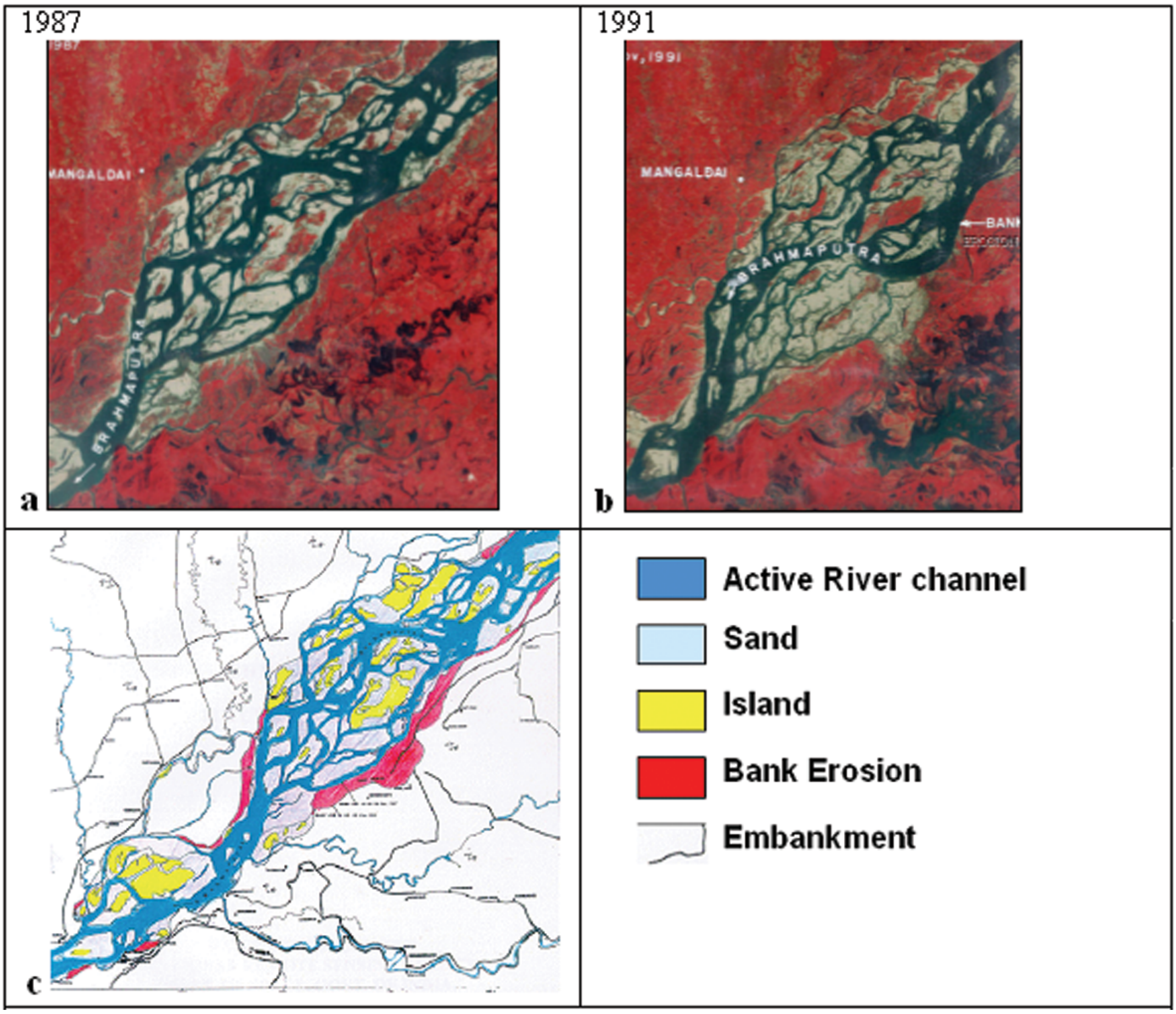

Figure 12.24: (a) Landsat –TM satellite image of 1987, (b) Landsat –TM satellite image of 1991 and (c) Bank erosion maps derived from 1987 & 1991 satellite data

shows post flood satellite data of 1987 and 1991 and the corresponding bank erosion map derived from the data set.

The post flood satellite dataset of 1990 and 1998 were analysed and the active river channel and river bank lines were delineated. These bank lines were intesected and the extent of erosion and deposition was estimated as shown in the figure 12.25.

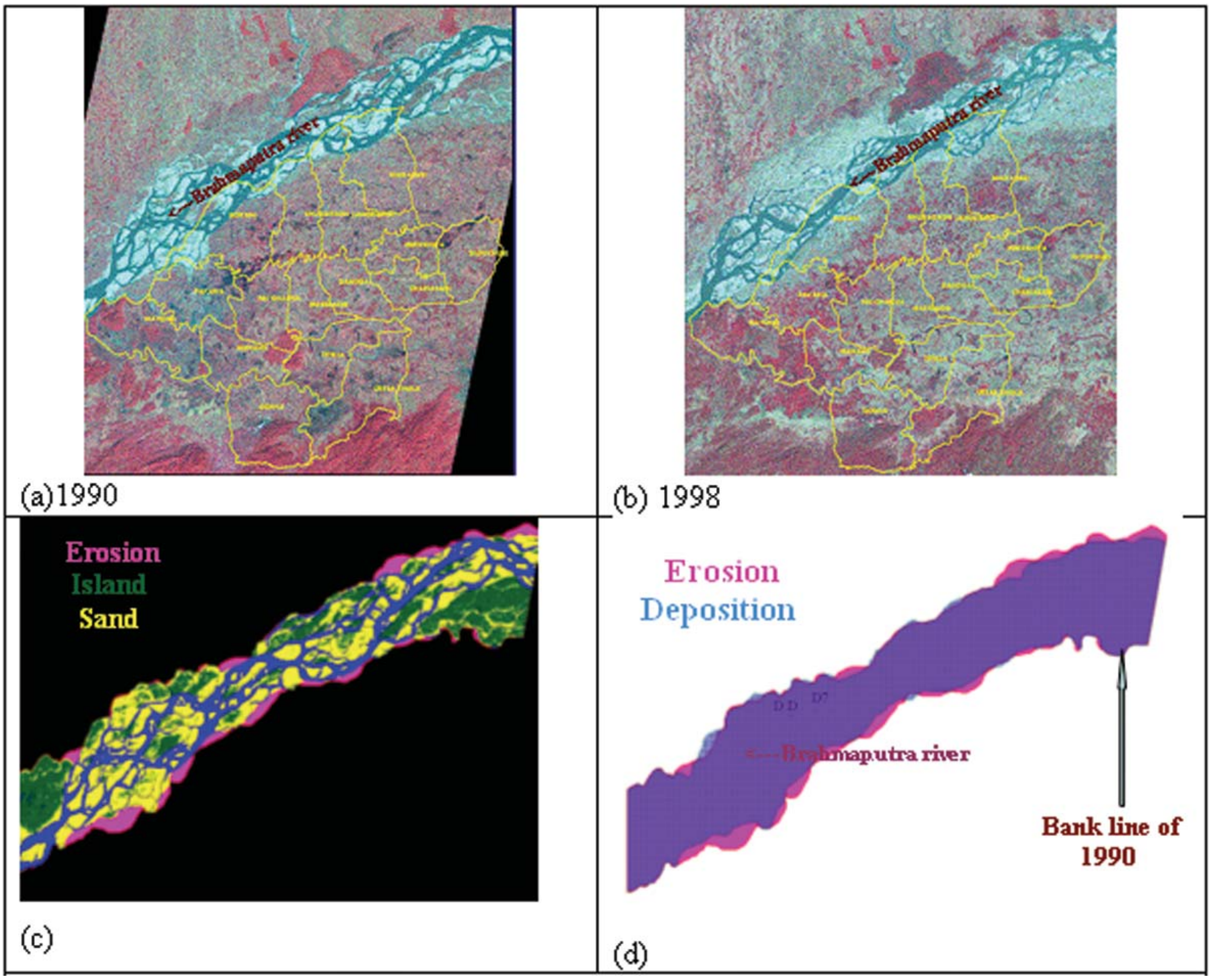

Figure 12.25: (a) Post flood satellite Images of 1990 (b) Post flood satellite Images of 1998, (c) Bank erosion and 1990 channel configuration and (d) Bank erosion map

12.5. Future Scope

12.5.1. Gap Areas

12.5.1.1. Optical

The presence of cloud in the satellite image would mask the flood affected area and it is not possible to provide the complete flood scenario. If minimum/partial cloud cover persists in the image, it is possible to delineate flood using spectral models. Therefore microwave SAR data may complement the optical data as an alternative. With the launch of RISAT, the first microwave satellite of ISRO and DMSAR, the dedicated disaster Airborne SAR, which has also got onboard processing, there is a possibility of availability of more microwave data for flood mapping and monitoring.

Sometimes, there is a chance of missing a flood event, in particular a flash flood in nature, if there is no satellite coverage immediately, may be due to longer revisit periods. In the worst case, if a flood occurs just after the satellite's overpass and the water recedes before the next satellite's overpass, from the satellite point of view, there is no flood. The spatial resolution of each image pixel may also be a constraint when identifying small areas or small patches of flooded areas in vegetated areas, agriculture fields, commercial and residential areas etc. In order to cover entire flood affected areas, particularly in India, large swaths are essential. Therefore, a constellation of Low Earth Orbiting satellites (LEOs) covering an area at regular intervals with different resolutions and swath may be a possible solution.

12.5.1.2. Microwave

In the microwave data, care should be taken in the shadow areas, smooth regions and areas disturbed by wind waves. Shadow areas do not yield any backscatter and are thus similar to ideal, smooth water surfaces. Flood in shadow areas can easily be remedied by masking out steep areas derived from the digital elevation model (DEM).

In addition to water, other surfaces like large roads, parking lots and especially airfields and runways can be smooth at radar wavelengths, and thus there is little or no backscatter. Using runways and roads from GIS database, we can be aware of potentially problematic areas and double check the likeliness of these structures being flooded.

The backscattered intensity of water bodies in SAR images increases with increasing wind speed. Thus, if the wind roughens the water surface enough to exhibit backscattering values equivalent to those on land, there will be no contrast between land and water. Therefore, large incidence angles are preferred to steep ones. But this parameter cannot be decided in a real situation, as the incidence angle depends on the location of the area of interest relative to nadir.

Today's space-borne SAR systems are polar orbiting, which yields global coverage, but with relatively long repeat cycles of 24 and 35 days for Radarsat and Envisat, respectively. By using variable incidence angles, Radarsat and Envisat are capable of acquire images from a given location with shorter intervals than the orbit repeat cycles. The frequency of how often a satellite SAR can cover a given area is dependent on the geographic location (latitude). Our experience is that it is generally impossible to get daily coverage with just one satellite, even with variable incidence angles.

12.5.2. Flood Modelling using LIDAR data

Digital Elevation Model of flood affected regions is a very important parameter in flood studies. With various limitations in optical and microwave data as discussed above, it is possible to overcome these with fine DEM.

12.5.2.1. River Forecasting

Introduction of remote sensing inputs such as satellite based rainfall estimates, landuse/landcover, soil texture etc., in the rainfall runoff models and integration of these databases in GIS environment considerably improves the flood forecasting capabilities.

A project on "Development of Flood Forecast Model and Spatial Decision Support System for Damage Mitigation" is initiated on R&D mode. The Godavari Basin is selected as a study area in the project as the Godavari Basin is one of the largest Indian River basins and floods are very frequent phenomenon in this river. The main objectives of the project are, Development of Flood Forecast Model, Flood Inundation Simulation using close contour DEM from ALTM DEM, and Development of Spatial Decision Support System for Flood Damage Mitigation. In total the project gives the end to end solution on flood disaster studies.

Spatial flood inundation simulation will be done using high resolution DEM and the output from the flood forecast model using MIKE software. Inundation simulations will be carried out for different flood scenarios in 2D modelling environment. A spatial decision support system will be developed for flood rescue and relief operations to mitigate flood damage. The process chain is shown in Figure 12.26.

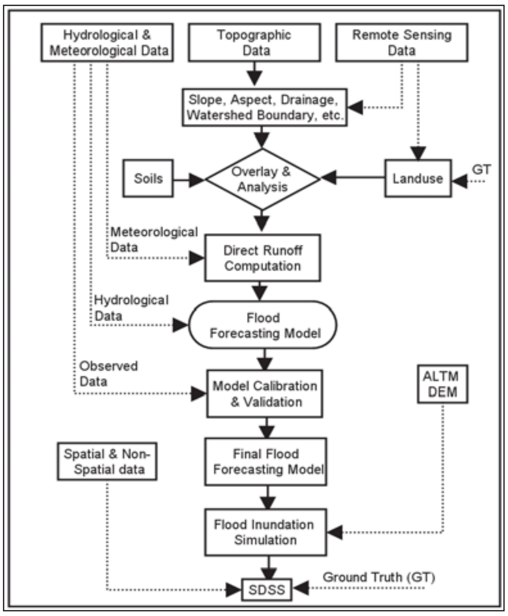

Figure 12.26: Flow chart showing the methodology

12.5.2.2. Urban Flood Modelling

Urban flooding has become a very severe problem in recent years worldwide. Urbanization has altered the timing and magnitude of flood peaks (Hazell & Bales, 1997). Hydrologic studies suggest doubling of flood peak magnitudes due to urbanization effects for a short duration and moderate intensity storms (Smith *et al.*, 2002).

As a watershed develops and rapid urbanization takes place, the land is covered with impervious surfaces like roads, roofs, parking lots, driveways, built-up areas etc., preventing rainfall entering into the ground. The result is that interflow is halted and now 80 to 90 percent of rainfall appears as direct runoff at the drainage inlets. Thus, runoff rates respond much more directly to the rainfall intensities, both in time and magnitude. A given rainstorm now produces significantly more runoff volume and more flow peaks causing severe stream channel erosion and flooding. With rapid urbanization across the globe and increased climate variability, urban flooding has been identified as a research priority (Wheater, 2002). Due to rapid urbanization, almost all major cities in India are frequently flooding even for high intensity small duration rainfall events in the recent years. The experience of floods in Mumbai and Chennai in 2005 has been one of the worst in the recent years (Saini, 2006). The management of urban flooding needs to be treated holistically in a multi-disciplinary manner. It becomes even more urgent with the fact that the migration to urban areas and an on-going development activities continue to be a threat causing an increase in the pressure on the various infrastructure and services provided. The risk of urban flooding disaster can be reduced by better town planning activities, hazard mitigation and prevention, improved preparedness and warning systems, well organized pre-emptive action and emergency response to minimize damages. Modeling of urban flooding by setting up different scenarios and analyzing their occurrence within a reliable modeling framework can help decision makers to identify the most effective actions.

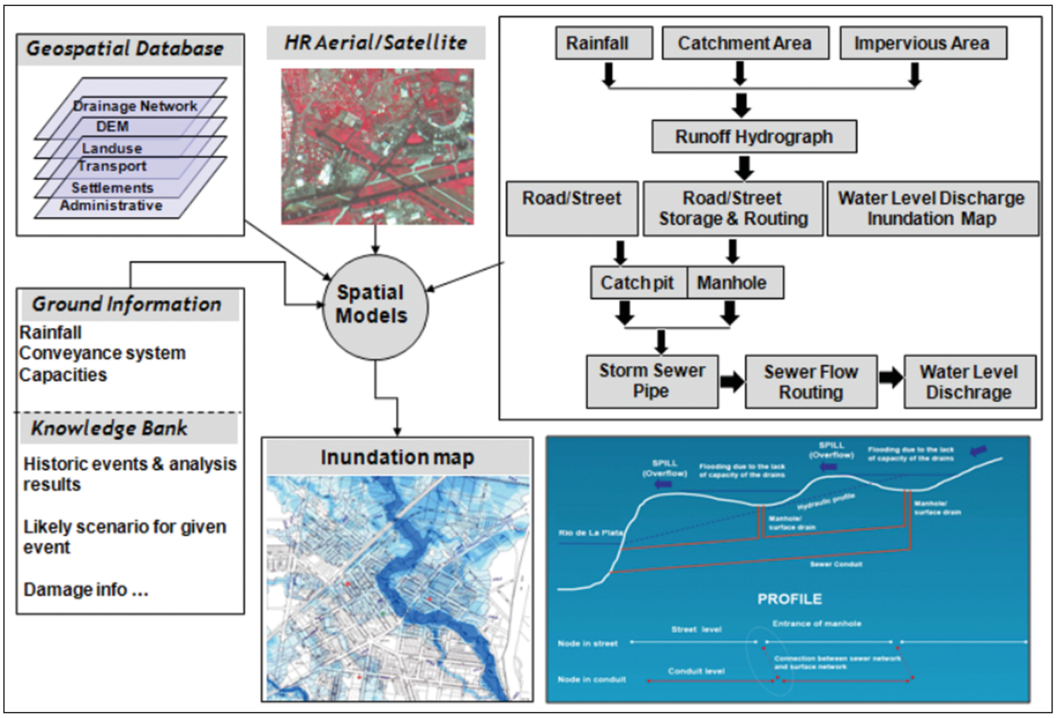

Figure 12.27: Geospatial approach for generating flood inundation maps for urban areas

High resolution terrain height data and landuse information are the two important inputs required to realistically budget floodplain storage and conveyance and the spatial distribution of resistance parameters. Rational formula / SCS curve number can be used to estimate the surface runoff from the urban catchments. Using the DEM generated from Lidar/ground survey, slopes of the study area can calculated. Delineation of suitable sub-catchments of basin can be carried out using the DEM. Distribution of the peak flow rates along the drainage network at different nodes can be estimated. The estimated peak runoff rate shall be compared with carrying capacity of storm water drains to judge whether estimated runoff will flood the area or not. The extent of flooding can be estimated using two-dimensional hydrodynamic modeling. For inundation simulation information on drainage

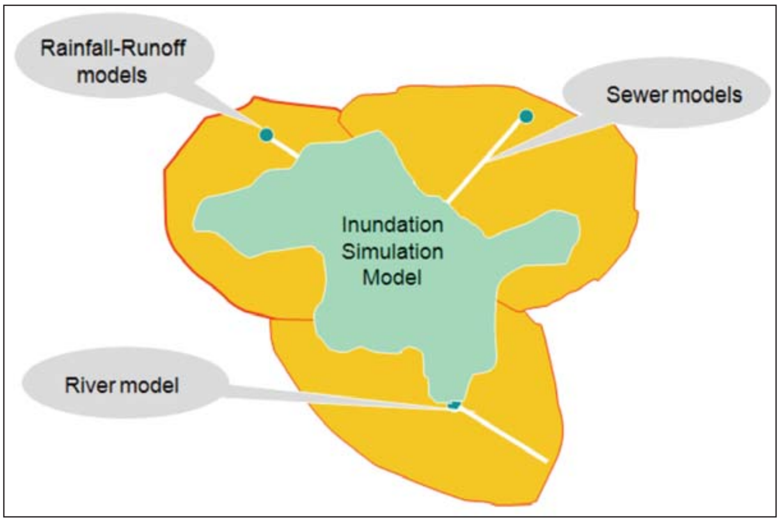

Figure 12.28: Integration of different models is required for modeling of urban floods (Source: http://www.coastms.co.uk/Conferences/Outputs.pdf)

characteristics like dimensions of the inlets, levels of the inlets and outlets, information on closed drains, open drains, type of drains etc., is required. Models like MIKE-MOUSE, SOBEK, UFDSM, etc., are being used for urban flood modeling. Figures 12.27& 28 shows the geospatial approach for generating flood inundation maps and integration of different models required for modeling of urban floods.

Figure 12.29 shows the early warning system installed for mitigating urban flooding in Mumbai, under Mumbai's urban flood disaster management and mitigation programme.

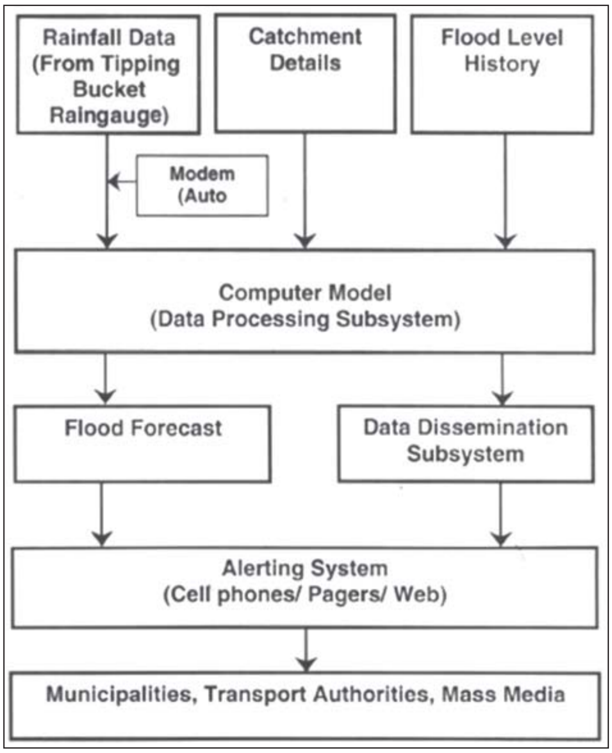

Figure 12.29: An early warning system installed for mitigating urban flooding in Mumbai (Source:http://nidm.gov.in/idmc/Proceedings/Flood/B2-%207.pdf)

12.5.3. Decision Support System

Geospatial database plays a major role in the flood management since it provides timely inputs meeting the user needs in terms of information content, format and multiple thematic layers integration and analysis. For this, a related Geo-spatial data with proper data standards formats and data access mechanism is essential. To achieve flood preparedness, mitigation, relief and rescue, Decision Support Systems (DSS) are effective tools for decision-making using available geospatial data sets in centralized data server. DSS is an intelligent information system for flood management and relief. It will be evolved through participation of knowledge institutions at user end using spatial datasets. It is also an electronic-based correspondence system and report generator that can be designed according to the user. SDSS will have two major modules 1) generic display & query module to facilitate display of spatial & non-spatial data, identification of attribute information, overlays, simple thematic queries etc., 2) analysis module catering to the specific needs pertaining to various phases of emergency management viz., early warning, damage assessment & statistics, risk prediction, evacuation plans & alternate optimal routes, proximity analysis, etc., using geospatial technologies.

12.5.3.1 Flood Management Information System (FMIS)

A prototype for flood management information system is planned to be developed for Government of Bihar to meet the operational requirements of different users involved in flood relief and rescue. It is planned to develop a standalone system on Desktop based architecture and it will have provision to view, access, update and create required outputs for flood management. A secured access to database is ensured and the users can run simple and complex queries on the data. The information system will also have Map / report generation. Figure 12.30 shows some of the sample utilities designed for FMIS.

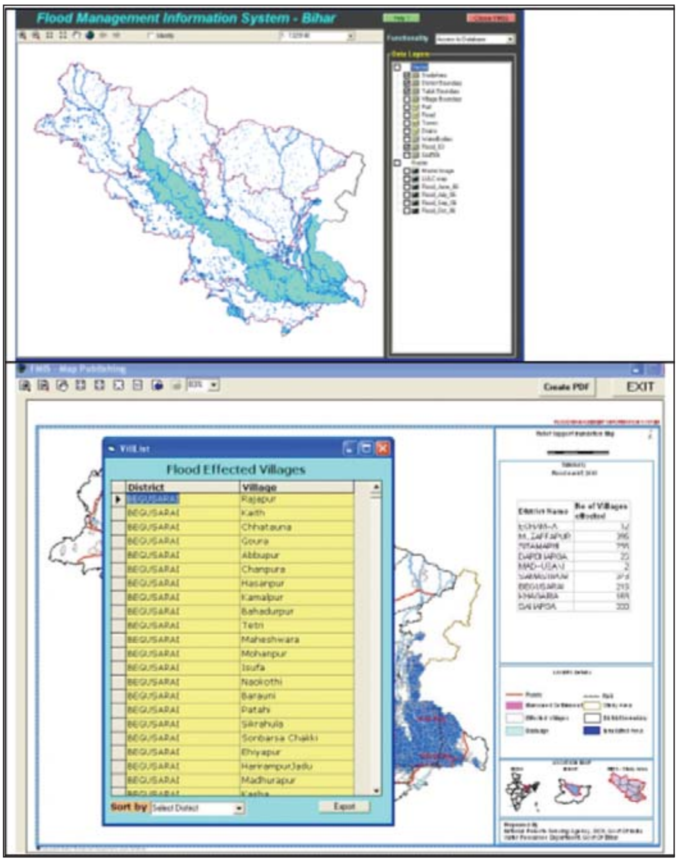

Figure 12.30: Sample utility displays designed for FMIS, Bihar

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