# WebGeoinformatics for Creating Schema & Interface for Mapping With Distributed GIS: Geomatics For Sustainable Societies

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*Abstract*: - The objective is development of an automated natural hazard zonation system with Internet-SMS warning utilizing geomatics for sustainable societies. At present no web-enabled warning system exists which can disseminate warning after hazard evaluation at one go and in real time. The functionality is to be modular in architecture having GIS-GUI, input, understanding, rainfall prediction, expert, output, and warning modules. Through this paper a significantly enhanced system integrated with Web-enabled-geospatial information has been proposed, and it can be concluded that an automated hazard warning system has been conceptualized and researched. However, now the scope is to develop it further. The research is aimed to create a dynamic and real-time spatial data infrastructure (SDI) solution by the way of continual sharable activity imparted by internet and ArcGIS/ArcIMS). At its core, the system is based on components GeoServer, GeoNetwork, Django, and GeoExt, that provide a platform for sophisticated web browser spatial visualization and analysis. Building on this stack, the present work utilises a map composer and viewer, tools for analysis, and reporting tools which are facilitated by ArcGIS/ArcIMS. It is designed on Web 2.0 principles to make it extremely simple to share data; easily add comments, ratings, tags connecting between ArcGIS/ArcIMS and existing GIS tools. To enhance distribution, the ArcGIS/ArcIMS enables simple installation and distribution; automatic metadata creation; search via catalogues and search engines. And to promote data collection the system is aimed to align incentives to create a sustainable SDI to align efforts so that amateur, commercial, non-governmental organisations and governmental creators all naturally collaborate, figure-out workflows, tools and licenses that work to assure data quality, inorder to promote data, constantly evolving, convincing and always up to date. The idea is to create a full featured platform for helping decision makers easily compose and share developments with spatial data.

*Key-Words*: - Internet-based, geo-spatial database, Knowledge engineering, data mining, short message service, interfacing, warning, communication, graphical interface.

## 1 Introduction

The joining of geospatial datasets is required to utilize the complete set of information available in each of them. There are many open source geospatial datasets available such as GeoNames, Open Street Map, Natural Earth and to get a comprehensive dataset with the union of all available information it is important that such datasets are linked optimally without redundancy or loss of information [1,2]. One of the essential aspects of digital mapping and online visualization of maps is the prioritized ranking of geolocations with respect to their attributes and this facility is available as rank columns in Natural Earth data tables which need to be merged with other datasets for creating a complete and exhaustive mapping example [3,4]. The underlying framework for creating a schema and web-based interface for sustainable smart societies has been presented in this research. The online mapping systems facilitate many geospatial datasets which are used, created, edited and maintained including the use of

GeoNames as the layer for populated places. Many of the geolocations on digital maps are not classified for importance because of the lack of additional information such as population or administrative level. A way to give an importance scale to the names is by linking the GeoNames to other datasets (OSM, natural earth). OpenStreetMap data provides a limited number of place classifications (such as city, town, village). For the best cartographic results we need classes that are a little more opinionated about how they rank cities [5,6]. Questions such as "Which of the labels should be visible" and "how much should this label be emphasized" are important decisions that need to be made in cartographic design. To do this the present research is to join additional information from Natural Earth, GAUL, SALB, GADM etc. The challenges faced include geometry searching, matching, buffer determination, local regional naming text inclusion and accuracy. This has been achieved by the current research work where presently GeoNames, Natural Earth and Open Street Map data tables have been merged with the union of all their attribute columns resulting in a complete geospatial dataset with place accuracy of atleast 95% for any given country dataset. The data tables at global level consist of hundreds of thousands of rows with each row depicting a geolocation. The geometry, name and geo-id complete and fuzzy searching and matching around a buffer of 50 km took a minimum of 30 secs to maximum 1 minute in a commodity computer with 2 GHz, 2 GB memory, according to size and complexity of the query run for a country which could have a list of points ranging from a dozen to several hundreds [7,8]. The future aim is to ultimately do this for global datasets to create an all-encompassing geodata bank having such information as administrative, political, ecological details from important databases as GAUL, SALB, GADM etc [9,10].

And this making of a city "smart" is emerging as a strategy to mitigate the problems generated by the urban population growth and rapid urbanization. Smart city architecture depends upon eight critical factors of smart city initiatives: management and organization, technology, governance, policy context, people and communities, economy, built infrastructure, and natural environment [11,12]. These factors form the basis of an integrative framework that can be used to examine how local governments are envisioning smart city initiatives. The framework suggests directions and agendas for smart city research and outlines practical implications for government professionals. Natural environment is an important criteria for future cities and urban sprawls. Smart city initiatives are forward-looking on the environmental front. Core to the concept of a smart city is the use of technology to increase sustainability and to better manage natural resources. Of particular interest is the protection of natural resources and the related infrastructure such as waterways and sewers and green spaces such as parks. Together these factors have an impact on the sustainability and livability of a city, so these should be taken into consideration when examining smart city initiatives. Integrative framework is the ideal way to move ahead. Drawing on the conceptual literature on smart cities and the factors, we have developed an integrative framework to explain the relationships and influences between these factors and smart city initiatives. Each of these factors is important to be considered in assessing the extent of smart city and when examining smart city initiatives. The factors provide a basis for comparing how cities are envisioning their smart initiatives, implementing shared services, and the related challenges [13,14].

This set of factors is also presented as a tool to support understanding of the relative success of different smart city initiatives implemented in different contexts and for different purposes. Similarly, this framework could help to disentangle the actual impact on types of variables (organizational, technical, contextual) on the success of smart city initiatives [15,16]. It is expected that while all factors have a two-way impact in smart city initiatives (each likely to be influenced by and is influencing other factors), at different times and in different contexts, some are more influential than others. In order to reflect the differentiated levels of impact, the factors in our proposed framework are represented in two different levels of influence. Outer factors (governance, people and communities, natural environment, infrastructure, and economy) are in some way filtered or influenced more than influential inner factors (technology, management, and policy) before affecting the success of smart city initiatives [17,18]. This counts for both direct and indirect effects of the outer factors. Technology may be considered as a meta-factor in smart city initiatives, since it could heavily influence each of the other seven factors. Due to the fact that many smart city initiatives are intensively using technology, it could be seen as a factor that in some way influences all other success factors in this framework, named **SmaCSys (Smart City System)** whose architecture is shown in Fig. 1 and GIS component in Fig. 2.

Fig. 1 : Shared Architecture of SMACSYS.

## 2 Methodology

The system is planned on using Open-Source Geographical Information System (OS - GIS) and distributed architecture based platform such as GeoNode maintained at geonode.org which is being contributed to by developers around the world. It allows 3 dimensional (3D-GIS) development. To develop on an open source platform is a very rare opportunity as far as spatial data infrastructures are concerned and this would be extremely vital when huge databases are to be created and consulted regularly for city planning at different scales particularly satellite images and maps of locations. There is a big need for spatially referenced data creation, analysis and management. Some of the salient points that would be able to definitely contribute through this project with GeoNode being an open source platform facilitating the creation, sharing, and collaborative use of geospatial data. The project aims to surpass existing spatial data infrastructure solutions by integrating robust social and cartographic tools; at its core, the GeoNode is based on open source components GeoServer, GeoNetwork, Django, and GeoExt that provide a platform for sophisticated web browser spatial visualization and analysis [19, 20].

Fig. 2 : GIS Data Flow Diagram component of SMACSYS.

Atop this stack, the project has built a map composer and viewer, tools for analysis, and reporting tools; to promote collaboration, the GeoNode is designed on Web 2.0 principles to: Make it extremely simple to share data; Easily add comments, ratings, tags; Connect between GeoNode and existing GIS tools; To secure distribution, the GeoNode enables: Simple installation and distribution; Automatic metadata creation; Search via catalogues and search engines (Google); And, to promote data collection, the GeoNode is aimed to align incentives to create a sustainable Spatial Data Infrastructure to: Align efforts so that amateur, commercial, NGO and governmental creators all naturally collaborate; figureout workflows, tools and licenses that work to assure data quality; To promote data, constantly evolving, authoritative and always up to date. The idea is to create a full featured platform for helping decision makers easily compose and share stories told with spatial data [21, 22]. Search via catalogues and search engines (Google); And, to promote data collection, the GeoNode is aimed to align incentives to create a sustainable Spatial Data Infrastructure to: Align efforts so that amateur, commercial, NGO and governmental creators all naturally collaborate; Figure out workflows, tools and licenses that work to assure data quality; To promote data, constantly evolving, authoritative and always up to date; The idea is to create a full featured platform for helping decision makers easily compose and share stories told with spatial data [23-25].

The techniques are useful for natural resource optimization, agricultural yield calculations and betterment, policy planning and long term goal setting. Domain specific Spatial Data Infrastructures (SDI) including data models, applications and services based on OGC standards and their benchmarking / evaluation are the objectives of this proposed research. The domains in which expertise is available are the ones for which SDI creation is intended in these domains. The initial architecture (Fig. 1 and Fig. 2) for the shared data concept has been elaborated and is shown in Fig. 3. The conceptual schema provides insight about the components and the way they are used to create the final product. The main components are: The GeoSpatial Data Manager, GeoServer, GeoNetwork, and Map Composer. GeoServer provides an OGC compatible data store that can speak WMS, WFS, WCS and others in common formats like GML, GeoJSON, KML and GeoTiff. It can be connected to different spatial backends including PostGIS, Oracle Spatial, ArcSDE and others. The Catalog: GeoNetwork-GeoNetwork provides a standard catalog and search interface based on OGC standards. It is used via the CSW interface to create and update records when they are accessed in GeoNode. As the Fig. 2 suggests, integration of knowledge bases for natural hazards to be developed to meet objective. The methodology is that system implements extraction, based on legend matching, of information about causative factors from thematic maps, satellite images, and GIS layers, addresses expert knowledge rules (qualitative approach), conducts pixel-based reclassification of input (compatible to KB) , results in evaluation of intensity of hazard on ratings of causative factors (deterministic method) and communication to user is achieved using existing cellular network infrastructure in a region.

The system methodology includes interpretation of causative factors from their input maps, addressing of expert knowledge as rules, reclassification of geomorphologic maps, evaluation of susceptibility intensity based on causative factors ratings, and minimization of subjectivity by fuzzy techniques. Further, the design of the system is primarily based on emulating expertise toward map preparation. Therefore, a hybrid method of analysis has been adopted for system development. The framework of a KBS consists of different functional modules such as an input module for data capture from thematic maps in digital form; an understanding module for extraction of relevant information from the input images; a knowledge module to make available domain expert knowledge through a knowledge representation scheme KRS; an inference module to provide a decision about the intensity of landslide susceptibility using the KB and inference strategy; and an output module to convey the decision of the expert module through digital display.

The system understanding consists of a matching algorithm based on the Complete Matching with Exact String Match approach. The algorithm is a variant of the brute force algorithm that has been adapted to the needs of the KB. It consists of checking at all positions in the string between 0 and n-m, whether an occurrence of the pattern starts there or not. Then, after each attempt, it shifts the pattern by exactly one position to the right. This algorithm requires no preprocessing in the understanding phase. That is to say that separate string arrangements, ordering, and indexing are not required unlike other algorithms, so processing overhead is less. The memory space requirement is also constant. Extra space is required only for the pattern and the text. During the searching phase the text character comparisons can be done in any order. The time complexity of this searching phase is O (mn), when searching for $m-1$ items. The expected number of text character comparisons is 2n.

## 3 Working Of System

The initial architecture for the shared data concept using the GIS-GUI module of the proposed system is shown in Fig. 3.

The input module is a highly interactive interface [13-15] having connectivity to GIS-GUI as well as Wireless Communication for warning module. The types of inputs correspond to the various causative factors sets for different hazard types. The Understanding Module is the intelligence embedded into the system for deciphering the input and access the correct knowledge-base. The understanding consists of a matching algorithm based on Complete Matching with Exact String match approach. The algorithm is a variant of brute force algorithm that has been adapted to the needs of the KB. This leads to understanding of the digital maps to correlate the information with the next functional module, i.e. the KB housed in the Expert module.

Fig. 3 : GIS Shared Architecture Distributed

Expert module houses the inference engine and knowledge database of the system [16-18]. The Output module (O/p) is responsible for accepting the classified hazard map and location based communication details. The Wireless Communication module is the warning functionality of the system and will be responsible for system information manipulation, processing and dissemination; Web-Content Handler sub-module for web-based processing; Trigger sub-module for Threat Extraction; and Communication sub-module for sending warning messages using interfacing with the GSM network. The GIS-GUI is to interface to the Input module of the system and is responsible for the features creation pertaining to geospatial datasets. This is proposed to be interactive and shareable in nature with functionalities like geodata shape files, attribute data, web-content graphics and the click and point interface. The two way communication with the input module allows the GIS-GUI to effectively create a client – server computer architecture (Fig. 3).

The input module in-turn communicates with the warning module to extract the mobile communication details which the user might want to display on the console via the GIS GUI. Domain specific SDI including data models, applications and services based on Open Geospatial Consortium (OGC) standards and their benchmarking/ evaluation are the building blocks of this proposed research, being taken care by the concept of GIS-GUI module. The conceptual schema (Fig. 1) provides insight about the components and the way they are used to create the final product. The main components are: The GeoSpatial Data Manager, GeoServer, GeoNetwork, and Map Composer. GeoServer provides an OGC compatible data store that can speak WMS, WFS, WCS and others in common formats like GML, GeoJSON, KML and GeoTiff. It can be connected to different spatial backends including PostGIS, Oracle Spatial, ArcSDE and others.

The Catalog: GeoNetwork: GeoNetwork provides a standard catalog and search interface based on OGC standards. It is used via the CSW interface to create and update records when they are accessed in ArcGIS/ArcIMS. This is a Django based project that allows the user to easily tweak the content and look and feel and to extend ArcGIS/ArcIMS to build Geospatial. It includes tools to handle user registration and accounts, avatars, and helper libraries to interact with GeoServer and GeoNetwork in a programatic and integrated way. There is a wide range of third party apps that can be plugged into a ArcGIS/ArcIMS based site including tools to connect to different social networks, to build content management systems and more. The Map Composer: ArcGIS/ArcIMS Client : The main map interface for ArcGIS/ArcIMS is the Map Composer / Editor. It talks to the other components via HTTP and JSON as well as standard OGC services.

The interactive graphical user interface allows for data visualisation, manipulation and sharing (Fig. 4) and it integrates with the broad functionalities of the system.

Fig. 4 : Conceptual Schema of geospatial data manipulation for open-source sharing in GIS-GUI.

The overall architecture depends on the creation of knowledge bases for natural hazards to deduce the extremity of the occurrence. The methodology is that the input module of the system implements extraction, based on legend matching, of information about causative factors from thematic maps, satellite images, and GIS layers, addresses expert knowledge rules (qualitative approach), conducts pixel-based reclassification of input (compatible to KB) , results in evaluation of intensity of hazard on ratings of causative factors (deterministic method) and communication to user is achieved using existing cellular network infrastructure in a region. Proposed research should contribute to the development and application of OGC standards. The proposal brings out the benefits of the study towards these goals and the overall requirement of setting up of SDIs in the country.

The proposed system architecture is based on the concepts of interactivity between geo spatial data management, internet and web-based processing, logical inferencing and communication technology. Hence the development of different modules, each of which achieves a specific set of tasks related to the mentioned technologies, such as the data needed by the geo-hazard warning communication system and the structure of data maintenance adopted inside the database module.

## 3.1 Input Data to the System.

The data utilized by the system comes in many basic formats like string, numeric, alphanumeric and arrays. The aggregated data is stored in the database as geo-referenced data, threat strings, communication numbers, and instructive messages if any. The data sets required by the geo-hazard warning communication system are as follows:

**3.1.1 Geo-Referenced Data.**

The information pertaining to assessed hazard and subscriber mobile data those have been registered in the system and mapped to the region (geo-referenced threat locations) where the messages are to be disseminated. The validation procedure works on landslide threat in a region evaluated a priory as a hazard map. The mobile numbers to be utilized for sending messages are the numbers lying in the region of the map. There could be many maps whose threat data are stored in the database of the warning system at any given time. To select the correct mobile numbers for that region, the hazard location as well as subscriber data both have been geo-referenced. The latitude and longitude for a given location describes the threat level in that location in one table and the same latitude-longitude describes the mobile numbers in that region. The separation of regions has been kept as 0.25˚ x 0.25˚ latitude x longitude. The latitude-longitude combination has been used as indexes for accessing the tables in the database.

**3.1.2 Location Data.** The location data consists of spatial as well as the threat details of an area, contained in the server database. The server database holds in its table *hazard_details* threat messages in association with their geo-location. The index column represents the pixel location of the rasterized hazard data having geo-referenced match with the ground location shown in the second column of the table. The classified hazard description constitutes the third column of the table which notifies the local area name as well. The geo-location in the second column is accessed by the client table described next.

**3.1.3 Subscriber Data.**

The subscriber data consists of the spatial details and the mobile numbers existing in that area, and populated with registered users. The client database stores the subscribers' registered mobile numbers in association with their geo-locations in a manner which corresponds to the format that the server database stores its geo-locations. Each entry from the first column of the client database table *client_location* is searched in the server database table *hazard_details* and on successful match, the location threat details are extracted from the server database table. The perceived threat in server database is matched with the hazard_string of the client database table. If the hazard_string occurs in the perceived threat string then the hazard level is confirmed to be correct and valid for use by higher modules of the geo-hazard warning system.

## 3.2 System Information Manipulation, Processing and Dissemination.

One of the tasks of each of the modules in the warning system is the handling of data received from the previous modules over the interfaces. Once the external hazard is received by the warning system the database module automatically creates data-tables to store it. It then keeps transferring the data through function calls to web-content handler module from the data-tables. Web-content handler creates packets of the data automatically and transfers it to trigger module. Trigger module utilizes the data and also creates its own data then calls a function to create the interface towards communication module. Communication module extracts the packet and calls the GSM interface system method to disseminate the message in the mobile network.

Through the *external_event* call to the geo-hazard warning communication system, it undergoes initialization with a fixed and distinct digital identification for each pixel which is a region having its distinct latitude-longitude information stored as DBMS tables. The system is coded in Java as this programming language has facilities for implementing internet-based and intranet-based applications and software for devices that communicate over a network. Java programs consist of pieces called classes. Classes include pieces called methods that perform tasks and return information when they complete execution. Java programs take advantage of rich collection of existing classes in the Java class libraries, which are known as Java Application Programming Interfaces (APIs). The connectivity with the database has been provided by developing a Java Database Connectivity – Open Database Connectivity (JDBC – ODBC) bridge with the help of JDBC-ODBC driver provided in the JDK [19-21]. This facility has been used by the system to obtain location and range of mobile network, and to store the output of the *external_event* as the input, i.e. the warning messages for the danger zones / areas.

### 3.2.1 Database Module : System Data Management.

The functions defined under the class *Database* are: *Connection Pool*, *Create Database*, *Initialize Server Database*, and *Initialize Client Database* function. The connection pool function creates connections to the data tables and maintains the list of open connections. The create database function utilizes a connection to latch on to the database to start creating tables, initialize database handles the read and append modes of data handling which are needed for both server and client data tables.

The various functions executed by the database module, as and when the requests come from higher modules, are: *Get Zone for Pixel* receives the pixel value as input and utilizes "Get Database Connection" sub-module to query the zone data associated with the pixel value; then invokes "Release Database Connection" and returns the retrieved zone (geo-location). Similar sequence of commands are executed for *Get Subscriber Data* to receive the geo-location (zone) as input and query all subscriber mobile numbers associated with the input geo-location and return the retrieved subscriber mobile numbers for the zone. *Get Location Threat Level* receives the geo-location (zone) as input and runs the query to access the threat level associated with the input geo-location and returns the retrieved threat message. Likewise there are other procedures for insertion, authentication and storage of server (operator) and client (subscriber) data available to the database module.

### 3.2.2 Web-Content Handler Module : Web-Based Processing.

Web-content handler creates the graphical user interface (GUI) environment of the system using HTML [22] and controls the web (internet) application data transmission applying HTTP [23]. This module receives the data from the database module and gets these encapsulated in the GSM SMS format [24-25]. Independent packet gets formed for each location consisting of, in sequence, subscriber number, and geo-location and threat message (Fig. 5). The packet has a header part at the beginning and a marker at the end. Finally, it sends the encapsulated packet to the trigger module of the system.

Fig. 5: The format of the data packet formed by web-content handler module for transferring.

The important parameters that the web-content module deals with are *gsmIncomingSMS*, *gsmPower*, *DebugFmt*, *clockNow*, *strConcat*, *dintToStr*, *boardSerialNumber*, *DebugMsg*, and *gsmSendSMS*. These functions and methods are incorporated for the packet formation and defining the utilities of the parameters for higher modules to which the web-content handler module sends the packets.

The communication module receives packet consisting of subscriber number, threat message and SMS frequency, in sequence. The primary objective of the communication module is to open the SMS sending utility and ensure that the communication goes through the correct gateway. The gateway is responsible for channelling data from internet to mobile network. The network communication broadcast facility will be used to freely send SMS (short messaging service) to all users of mobiles moving into an area affected and perceived threat prone. The SMS sending utility is invoked / opened by the communication module and is entered with the initial parameters such as username, password and application identity (API ID). These initial parameters are required for authorising the delivery of each SMS, hence the communication module inserts these parameters into the SMS program each time the program is called.

The warning system uses the location details from the server database and accesses the threat message strings corresponding to each. In its client database, the warning module has the mobile numbers in a pre-determined storage format. Hence, as soon as the mobile numbers in the region are extracted from the table, the SMS Protocol program is called and the mobile numbers filled in the program as command line parameters and the respective hazard messages are sent. The number of mobile numbers selected per region is fed in a loop and the SMS program is called for each number for sending SMS.

**3.2.3 Interfacing with the GSM Network.**

The internal processing involving the database and web servers maintains the actual data flow controlled by the http/s and TCP/IP commands. When a http request is generated by the system after creating the data packet, server hosting web-content module starts processing the requests and accesses the database through a TCP/IP channel. Further internal processing involves the function calls in sequential manner to the trigger module and communication module. The communication module executes the server command ComX (present in *attention (AT)* command-set) to connect to the modem over a physical channel RS232.

The AT commands follow a sequence as per the logic within the system. The logical steps of sending an SMS are as follows: the first step verifies the authenticity of the user. In the second step, appropriate SMS message body (consisting of gsm_number, sender_name, text_message, name_of_packet, gateway_identification, quality_of_message and delivery_code) is created to ensure the message gets delivered to correct users. And if not, then negative acknowledgement gets sent. As soon as a message is ready to be sent, a connection gets opened, for permissible login SMS gets sent and on detecting the final header of SMS, the connection is closed. The cycle repeats for each SMS.

Hence, as soon as the mobile numbers in the region are extracted from the table, the SMS protocol program is called and the mobile numbers filled in the program as command line parameters and the respective hazard messages are sent. The number of mobile numbers selected per region is fed in a loop and the SMS program is called for each number for sending SMS. The SMS program connects to the SMS gateway via the internet and this gateway forwards the message to the mobile numbers.

The communication module is equipped with two ways of interfacing with the GSM network to send SMS messages from the warning system to mobile phones. The two methods are:

1. Connectivity of the geo-hazard warning system to the SMS center (SMSC) or SMS gateway of a wireless carrier or SMS service provider through the internet. Subsequently the communication module sends SMS messages using a protocol / interface supported by the SMSC or SMS gateway. This is the software method of message sending.
2. Connectivity of GSM modem to the geo-hazard warning system and execution of AT commands to instruct the GSM modem to send SMS messages. This is the hardware method.

The SMS gateway is the responsible entity to disseminate messages in an SMS messaging system. Hence, the developed system utilizes programming interfaces to SMS gateway (Fig. 6) using an open source SMS gateway software package Kannel (Kannel, 2010), which is programmable. Through Kannel the geo-hazard warning communication system can handle connections to SMSCs, mobile phones and GSM modems. It has an HTTP / HTTPS interface for the sending and receiving of SMS messages.

Fig. 6: SMS gateway acts as a relay between two SMS centers.

To connect to an SMS gateway, the developed system uses an SMSC protocol called SMPP (Short Message Peer to Peer). Some features of the developed SMS application are programmed using the HTTP / HTTPS interface also. HTTP / HTTPS are easier to use than SMSC protocol SMPP.

The JAVA class containing the above methods supports many of the URL parameters that are defined for the warning system communication module application, and could easily be adapted to support additional parameters. The URL parameters are supported as methods for the *sendsms* class, with *methodnames* matching the URL parameter names, except that all methods are in lower case.

## 4 Conclusions

The intensity of natural hazards in any region is an important parameter for many engineering activities but it is a cumbersome process to assess it manually. A system having capability to prepare a map depicting intensity of any natural hazard and dissemination hazard information to affected users would be helpful for different activities. For various disaster management and mitigation activities as well as for convenience of non-experts such a solution is worthwhile. It is known that given an input of causative factors and a knowledge base capable of inferencing output from input, susceptibility zonation can be done. The approach is to demarcate different functions experts perform to prepare a susceptibility map, be accomplished through equivalent functional modules in system. Broadly, Input Module, Understanding Module, Expert Module, Output Module, and Wireless Communication Module would constitute system. Currently, our model is in place for landslide susceptibility warning which has a design generalized enough to be used for or types of natural hazards We utilize an inference scheme to categorize a region into different intensities of landslide susceptibility and propose web-based programmed applications and solutions to disseminate hazard warning SMSes. The work has to progress in direction of including remote sensing satellite images and GIS layers as input, and also creating knowledge bases for different hazards viz. flood, earthquake, cyclone, forest fire etc. Early warning and impact assessment mapping of natural hazards using Open Source Geographical Information Systems (OS - GIS) based platform such as GeoNode maintained at geonode.org and contributed by ITHACA, Politecnico di Torino. GeoNode is an open source platform that facilitates the creation, sharing, and collaborative use of geospatial data. The project aims to surpass existing spatial data infrastructure solutions by integrating robust social and cartographic tools and studies using Information technology, Geo-informatics and ICT for sustainable development, etc.

The interactive graphical user interface allows for data visualization, manipulation and sharing (Fig. 2 and 3) and it integrates with the broad functionalities of the system as in Fig. 1. The overall architecture depends on the creation of knowledge bases for natural hazards to deduce the extremity of the occurrence. The methodology is that the input module of the system implements extraction, based on legend matching, of information about causative factors from thematic maps, satellite images, and GIS layers, addresses expert knowledge rules (qualitative approach), conducts pixel-based reclassification of input (compatible to KB) , results in evaluation of intensity of hazard on ratings of causative factors (deterministic method) and communication to user is achieved using existing cellular network infrastructure in a region. Proposed research should contribute to the development and application of OGC standards. The proposal brings out the benefits of the study towards these goals and the overall requirement of setting up of SDIs in the country. The proposed system architecture is based on the concepts of interactivity between geo spatial data management, internet and web-based processing, logical inferencing and communication technology. Hence the development of different modules, each of which achieves a specific set of tasks related to the mentioned technologies, such as the data needed by the geo-hazard warning communication system and the structure of data maintenance adopted inside the database module.

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